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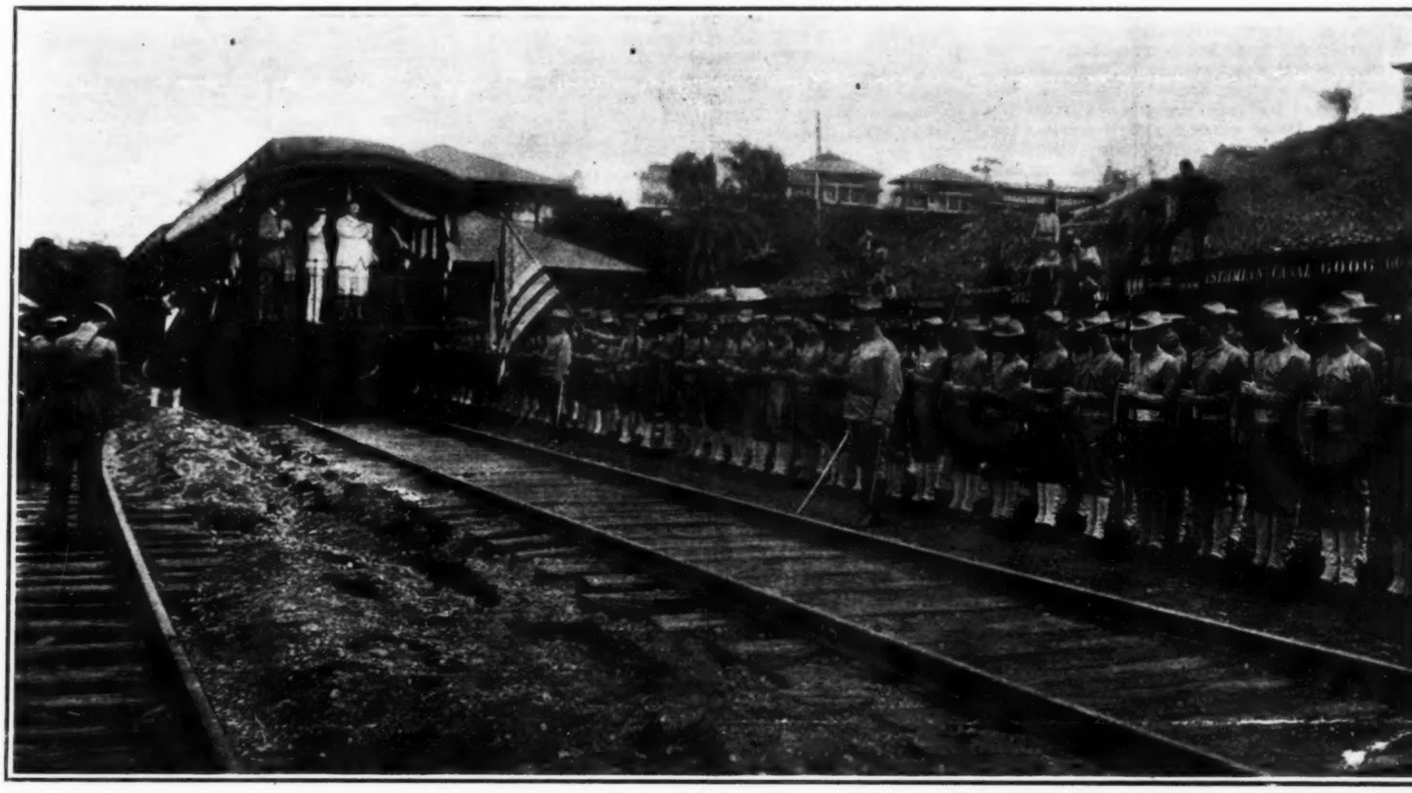


REVIEW OF MARINES AT CAMP ELLIOTT. THE BAND IS PLAYING THE "STAR SPANGLED BANNER."

STONE CRUSHER AT WORK AT BAS OBISPO.

THE PRESIDENT'S STORY OF HIS VISIT TO PANAMA.—[SEE PAGE 25908.]

THE PATENT FACTORY.

By George Ethelbert Walsh.

Contrary to a rather widespread impression an invention is generally a growth rather than a sudden inspiration. Moreover, it is often the product of several minds working along parallel lines, each contributing its quota of experimental knowledge. Forecasting an invention is not an impossible feat. The need of some sort of time-saving or labor-saving device is felt in an industry. Experts are called in and the ground thoroughly canvassed, impracticable methods eliminated, and the most feasible systematized and described. Then the work of developing the invention is turned over to experts, or rather to professional inventors, who can roughly forecast what they will do.

The conditions of modern industry demand the elimination of chance and uncertainty so far as possible. Inventions have upset business and manufacturing interests more than any other factor in the last ten years. The installation of expensive machinery is a costly undertaking if some inventor comes along with a patent six months later which practically makes the machinery ancient and obsolete.

"Last year," confessed a leading manufacturer of novelties, "my plant was practically knocked out by the invention of a device which makes it possible for my rivals to save $50,000 a year. I must either go out of business or invest in new machinery and pay big royalties to the inventor. This periodical revolutionizing of conditions by new inventions is one of the disturbing features of manufacturing. Is it any wonder that big concerns keep a sharp lookout for patents and even employ an army of experts to watch the applications for new patents?"

The professional inventor works better in co-operation with others interested in similar subjects, the deficiencies of one thus often being supplied by another. Associations of inventors have therefore become important organizations in this industrial age, and most of our great patents are products of one of these "patent factories" rather than of a single individual.

Edison's patent factory is not an exception to this rule, for while his personality dominates the establishment over which he presides, and credit is given to him for the inventions, he has surrounded himself with experts whose labors contribute to the general cause. Not only is the great "wizard" relieved of a great mass of detail work by his assistants, but suggestions and experiments are constantly coming to him from his associates. In his "patent factory" he employs some of the best chemists and mechanical experts in the country. Work of an experimental nature is intrusted to them which would require years of patient toil from a single inventor without the equipment of the modern plant.

Tesla is another great inventor who conducts his own "patent factory." With one of the best-equipped electrical and experimental laboratories in the world, he has surrounded himself with bright young men who have succeeded in chemistry, electrical sciences, mechanics, and physics, and his labors of inventing are systematized to the point of simplicity. Most of Tesla's important discoveries in electrical science were predicted years ahead of their ultimate perfection, and the work of making good his promises has established for this inventor a unique position in the world of electricity.

Another important "patent factory," which differs from these two in some important respects, is the Ampere Electrochemical Company of Niagara Falls. Instead of a single dominating mind heading this plant, half a dozen inventors compose the company and direct its affairs. The company is not an operating concern, but purely an experimental organization or association of inventors. The object of the "patent factory" at Niagara Falls is to delve into the mysteries of electrochemistry for the purpose of discovering new processes for commercial application; but when a new patent is developed it is turned over to an operating company for exploitation. The inventors themselves have no interest in the applications of their patents.

The founders of this strange "patent factory" are men well known in the world of electrochemistry. Prof. F. B. Crocker, C. A. Doremus, S. S. Wheeler, and C. S. Bradley were the original organizers of the experimental plant, and later they had associated with them A. H. Buch, D. R. Lovejoy, H. E. Knight, N. Thurlow, and Charles B. Jacobs. The results of this "patent factory" are evident in a hasty glance at some of the most important electrochemical industries which have grown up around Niagara, where a vast amount of electric current can be had at small cost.

To this "patent factory" can be traced the discovery of the present method of making artificial corundum by fusing bauxite by a patented process; the work of obtaining nitric acid from nitrogen and oxygen by electrical methods; the different processes of utilizing and producing barium sulphate and barium salts for the purification of our drinking water, and the production of artificial camphor from turpentine at Port Chester, which a few years ago failed after a short experimental test.

The large industrial and manufacturing companies have in recent years established "patent factories" of their own, where experts conduct tests and experiments along certain well-defined lines for mutual interests. These commercial "patent factories" are equipped with the best laboratories in the world, and men of genius and experience preside over them. The association of half a dozen experts in such a plant tends to make the work of discovery and invention simpler and more practical.

The General Electric Company spends tens of thousands of dollars every year in supporting its "patent factory." The presiding genius of this plant is Dr. C. P. Steinmetz, an inventor of world-wide fame. He has to his credit a long list of patents which have helped to bring the generation, transmission and application of electricity up to their present-day efficiency. With him are associated men of almost equal gift for invention and specialists in certain fields. The total output of this factory averages scores of new patents and improvements upon old ones every year. Any employee of the company who has a promising idea is encouraged to present it to the head of the "patent factory," and if considered of value it is exhaustively tested and tried by experts. While the company holds all the patents developed by any of its employees, proper remuneration is made to the inventors, so that each one is stimulated to make suggestions and improvements. Frequently the development of a patent is more dependent upon the opportunities of the inventor to make exhaustive experiments with costly machinery and tools than upon the initiative impulse of the individual. Thus many valuable patents of to-day would never have been perfected had the inventors been forced to rely upon their individual means and work.

The Westinghouse Electric and Manufacturing Company is another representative concern which has a well-equipped "patent factory" in operation in connection with its manufacturing plant. Many valuable patents are taken out by this company, and most of them are traceable to the energy and foresight of the professional inventors employed by the company.

Another important "patent factory" is that of the Western Electric Company, which has to do largely, although not exclusively by any means, with telephone patents.

The various large concerns owning their own "patent factories" are rapidly specializing the work of inventing. The electrical manufacturers confine their attention to inventions in their industries, and the makers of special machines limit their tests and experiments to machinery in their particular line. The Ampere Electrochemical Company makes no efforts to invent dynamos and motors and equipments, but studies only the field of electrochemistry. Iron and steel mills find it more convenient and economical to confine their labors to the perfection of details of their plants and rarely branch out into other industries. In this way inventions are becoming specialized, and the professional inventor devotes his time and genius to certain departments of work.

The possibilities of inventions are probably greater in the electrical and electrochemical fields than in any other to-day. The electrochemist, in particular, has many untrodden paths ahead of him. By the aid of the electric current changes have been effected in the sugar and paint trades which make for efficiency. Electrochemists are to-day working with promise of success toward the manufacture of starch from by-products. Artificial rubber of fair value has also been produced, and the cyanides, silicides and ammonia are all promising products for the electrochemist. Synthetic electrochemistry is generally recognized as one of the greatest future businesses of the world; and that the Falls of Niagara were created for this purpose is the opinion of the workers in this field.

While the individual inventor may find his opportunities somewhat circumscribed by these changes, the gain obtained through the organization of professional inventors is great. Greater results flow therefrom, and the young man associated with a modern "patent factory" secures in time a training which makes his inventive gift of far greater value to himself and the world. In the field of discovery and invention of to-day expensive and elaborate tools and laboratory equipment are frequently essential to success, and the modern "patent factory" supplies these requirements.—Western Electrician.

THE MOTIVE POWER OFFICER OF A GREAT RAILWAY.*

American railroads are usually built along the lines of least financial resistance, and improvement problems in grade reduction and curve rectification were handed down to the present generation of managements. Improvements in yards, at terminals, and at points in transit simplify the handling of freight, and soon the locomotive will receive its share of development. Heretofore, it has grown chiefly in size, weight, and power, but there remains another development in the direction of crowding the greatest possible capacity for power within the possible limits of weight and size. Economy of operation, while important, is less important to-day than the provision of the utmost possible capacity of the machine. Perhaps this may be more clearly stated by saying that the greatest need is for that which will extend to the utmost the capacity of the fireman and render the limited physical strength of a man capable of supplying the requisite power.

This is the locomotive problem for the immediate future—to provide more power without greatly increasing existing weights. A secondary, but scarcely less important, field for effort is the improvement of design and method of operation which will reduce road service failures.

Another opportunity for the greatest abilities lies in revolutionizing methods of motive power management to bring them into parallel with those methods which have brought the greatest successes in the management of vast industrial establishments. Altogether the motive power problem presents possibilities as great as those of any field of mechanical activity, and these are worthy of the efforts of the best of men.

Thirty years ago the head of the mechanical department led a comfortable life. He could safely follow precedent, and the strenuous life had not been invented. Labor wars had not begun and the stirring emergencies of the present were unknown. It was easy to select shop machinery. There was no shop problem, no pooling of locomotives, no piecework price, no heavy locomotive or large capacity car, and no train four-fifths of a mile long. No one cared much about the records of performance or cost of work. Workmen were better trained and good apprentice systems were in force. There was no tendency to go outside of a railroad organization to secure any official, and railroad ways and methods were those of smaller days. There were emergencies, of course, but not the emergencies of to-day. Thirty years ago the railroad official was a good man and as efficient for the time as the official of to-day, but he was a very different kind of official. His facilities were crude and his responsibilities not so great. Locomotives did not weigh 50 tons and other factors were in proportion. The superintendent was his own general manager and he knew every man in the train service. The master mechanic knew all his shop men and the engineers and firemen. He knew their history and he knew all about them and their affairs. Each locomotive had a name and an engineer and fireman were assigned to it. They went into the shop with their engine or they were laid off while it was repaired.

We have no desire to return to the old methods, but those methods are now worthy of a thought, because while all conditions of service have greatly changed, we have not changed enough in our views as to the proper management and organization of the motive power departments. The past has left us a somewhat unfortunate legacy, of which the result only needs attention on this occasion. The result referred to is seen in the tendency for young men to be easily enticed away from railroad service after they have spent years in preparation for it and are fairly on the road to win success. As a legacy of the earlier days of railroads in this country motive power positions are not, as a general rule, made sufficiently attractive. This, however, is to be changed and the power to bring the change lies in the young men who now hold responsible motive power positions and in those who are to hold them in the near future. As motive power problems and possibilities become better appreciated and better understood, the railroads will surround motive power positions with greater attractions, which will eventually render it thoroughly worth while for the very best mechanical talent to prepare for work which, because of its attractions, will preserve this talent to the railroads. There are signs on the horizon to-day that this happy state is coming soon.

As to the locomotive problems of the present we have a few like these: Shall the next lot of passenger locomotives be single or double expansion? Shall we experiment to-day with superheating? Shall we order balanced compounds? Shall we not adopt improved valve gear? For the next very heavy freight locomotives shall we order articulated compounds? Shall we brave the criticisms of those who worship simplicity and order really better locomotives, even if a few complications are involved? In the shop problem, shall we or shall we not organize and operate large plants upon the well understood principles which have made large manufacturing enterprises successful? In the next order for 10,000 cars, shall we use all-wood, all-steel, or composite constructions?

These are live questions and those who are to decide them need to understand the reasons why they are presented and why they are pressing.

Shall the next lot of passenger locomotives be single or double expansion? Compounds, because of their favorable use of steam by dividing the range of expansion and the range of temperature changes in the cylinders, are more economical in the use of steam than are simple engines. This improves the efficiency of the locomotive as an operating unit, which is more important than economy. There is less cylinder condensation in a compound because the division of the expansion between the two cylinders reduces the range of temperature, and, therefore, reduces the amount of moisture condensed from the incoming steam for the next stroke. A further advantage in the use of compound cylinders which applies to the three and four-cylinder types lies in the fact that the steam is divided into smaller installments and not so much steam is required to pass through a given number of steam ports and passages. This renders a three and four-cylinder compound "quicker on its feet" than single expansion locomotives of the same capacity, and, as a matter of fact, the highest speeds in regular train service in the world are made with compound locomotives.

It may seem strange, in view of the superior economy of compound locomotives, that they have not been adopted generally in place of single expansion locomotives. Compounds are apparently increasing in favor at the present time, and this is to be explained rather on the ground of the increased capacity which they render available than because of their superior economy. It is claimed by those who have used compounds and discarded them that the additional cost of maintenance, because of the somewhat increased complication, more than offsets the advantage gained by saving a little fuel. While this may have been true some years ago, it is not believed to apply to the more recent types of compounds, and it may even be claimed at the present time that the feature of econ-

* Address by Mr. G. M. Basford, of the American Locomotive Company, delivered before the Mechanical Engineering Society of Purdue University.

omy may be disregarded. This is because of the very much more important attribute of the compound in applying increased capacity. At the present time railroad men are so anxious to secure the utmost possible capacity that they are willing to accept some additional trouble and expense in maintenance in order to secure the additional power which every railroad now requires in order to deal with trains of increasing weights and speeds. Reliability of service in summer and winter is now becoming very important in competitive passenger service. For this, reserve capacity is necessary.

When a railroad official faces the increasing weight of trains and increasing severity of schedules, he is ready to grasp at anything which will help him out of the difficulty. Because compounds do increase capacity, young men who are now preparing to enter motive power service will find it advantageous to have well-defined opinions as to the possibilities of the compound to meet future requirements which are going to be more difficult than those of the past or present. When the question of locomotive design is raised on a railroad where an additional car must be hauled and the time must be somewhat shortened, the compound locomotive stands ready at hand to meet this need. Those who are most competent to judge believe that the locomotive of the future is sure to be a compound.

Shall we experiment to-day with superheating? Superheated steam offers a very attractive field in connection with locomotive development. In German practice it has been remarkably successful, and the Canadian Pacific Railway has practically duplicated the satisfactory results obtained in Germany. A number of experiments are now being made in this country, promising very satisfactory results. In short, superheating is one of the fundamental questions in locomotive practice which is worthy of most careful attention at this time.

Superheating does not seem to be antagonistic to compounding, but it serves in the same general direction to reduce heat losses in the cylinders. Condensation of steam in locomotive cylinders and passages robs the locomotive of a great deal of its power and, in cold climates, this becomes a serious matter. It will always be difficult to protect thoroughly the cylinders and steam passages from radiation, and, therefore, other precautions may be necessary to prevent the loss of heat from lessening the power of the locomotive. Superheated steam, coming into the cylinders at high temperature, as it does, permits of a larger loss of heat before producing condensation than is possible with saturated steam where the margin for loss without condensation is very small. Superheated steam may lose to the cylinders and passages a much larger proportion of its heat before condensing, and in this lies the chief advantage of its employment. Superheated steam is also quicker than saturated steam in its movements through passages and ports, as is proved by the fact that in Germany 7-inch piston valves suffice for ordinary passenger locomotives.

Such a principle as this cannot be applied to a locomotive without incurring some trouble and expense. While the improvement in the efficiency and economy of the locomotive is very readily attained, it is quite possible that it may be attained at too great an expense of restricted mileage and cost of maintenance, and it is always necessary to nurse a new development in order to make it practically successful. The question at the head of a prior paragraph should be answered in the affirmative because the possibilities of superheated steam at the present time seem to be exceedingly important and it is perfectly safe to spend the time and money necessary for experimenting because of the practical certainty of the results.

Shall we order balanced compounds? The subject of balanced compounds really requires a paper by itself. Locomotives have become too large to permit of continuing indefinitely the mere increase of size and weight. More scientific development is needed. The usual methods of counterbalancing answer very well for comparatively light engines, but as locomotives become larger and the parts become heavier the internal stresses upon the engine itself, due to the inertia of the parts, and the effect upon the track of the unbalanced counterweights render it necessary to devise a better scheme of balancing. In ordinary practice counterweights are added to the driving wheels for the purpose of balancing the reciprocating parts, but the revolving weights themselves need balancing when near the top and bottom of their paths. When in these positions the counterbalance weights tend to change the weight on the driving wheels, due to their centrifugal action, acting vertically upward when the weights are near the top of their path, and acting vertically downward when they are near the bottom. The counterweights, therefore, tend to lift the locomotive in the one case, and tend to increase the weight on the rails in the other case. This causes the so-called "hammer blow" upon the rail, and because this so-called "hammer blow" sometimes amounts to 25 per cent of the static weight on the rails, it becomes exceedingly important in limiting the weight allowed upon driving wheels. By using four cylinders and balancing reciprocating parts with other reciprocating parts, and revolving weights with revolving weights, a practically constant pressure on the rail is secured which renders it permissible to increase the weight on the driving wheels without increasing the destructiveness upon the track. By this permissible increase of driving wheel load a larger boiler may be carried, which is greatly to be desired in locomotive practice to-day.

On the Pennsylvania testing plant at St. Louis the Cole four-cylinder balanced compound operated for a full hour at a speed of 75 miles per hour, thus indicating a remarkable capacity. Incidentally, economy of fuel and water constitutes attributes of this type of locomotive, and in the constructive features it is found to be possible to lighten the parts materially because the work is divided among a larger number of them. The subdivision of the power reduces the fiber stresses on each of these parts and the disturbing influences of very heavy rods and reciprocating parts are avoided. The effect of reciprocating parts upon the structure of the engine, as the movements of these parts rapidly change in direction, has probably never had the attention which its importance merits. For high-speed passenger service, and also for freight service, the four-cylinder balanced locomotive presents advantages which should be tested to the utmost.

Shall we adopt improved valve gear? Many efforts have been made to improve locomotive valve gear. These have been directed toward an improvement in the distribution of steam, and also to improvements in mechanical construction. Entirely aside from possible improvements in the distribution of steam, the valve gear of American locomotives of very large size presents an opportunity for structural improvement which, at the present time, is extremely important. The present tendency toward the use of Walschaert valve gear is due chiefly to the desire to improve structurally rather than to improve the use of steam. It is considered advisable to remove the valve gear from a confined space, under the locomotive and also, if possible, to lighten the parts and arrange them in direct lines. The Walschaert valve gear does this, and more. It substitutes easily-maintained joints and pin connections for the very large and inaccessible eccentrics and it provides an arrangement which is not as liable to derangement as is the Stephenson motion.

For the next heavy freight locomotives shall we order articulated compounds? Heretofore the locomotive has grown generally in size and weight, without radical change in principle to meet conditions of growth which cannot properly be made through the application of the brute strength idea in design. Large freight locomotives of ordinary types now involve single parts so large as to be difficult to handle in the shop. Their very size gives evidence of the stresses to which they are subjected, and it is believed that the time has arrived for dividing the power and work of the freight locomotive into a larger number of parts as is done in the case of the Mallet articulated compound, which has now been successfully running for over a year on the Baltimore & Ohio Railroad. This locomotive weighs 477,500 pounds, including tender, and is the heaviest and most powerful ever built. A glance at this enormous machine immediately indicates the absurdity of designing it upon the basis of two cylinders. This locomotive has operated so successfully as practically to establish the principle of the articulated compound for locomotives which are not nearly so heavy. This general subject of the large freight locomotive is one which now needs, and will continue to need, the attention of those who are preparing to deal with the problems of the next few years.

These questions are not to-day always placed before motive power men for final decision, but these are some of the real mechanical department questions which motive power men should be permitted to decide, and if they are decided by the right men, many factors of railroad operation will be revolutionized. To the future, other questions may be left, but the answers must not be long delayed.

It is necessary to decide upon suitable recruiting methods, upon improvements in organization and methods of dealing with the rank and file, as well as with the officers and subordinates, to produce a stream of developed talent toward the shop, where it is soon to be more greatly needed than ever before.

What is the locomotive of the future to be? It will be a steam locomotive for a time and then electric. In many places traffic is now sufficiently congested to render electric locomotives attractive, but before the steam locomotive becomes a mere curiosity there remains much for it to do, and its development and its improvement are by no means ended. The electric locomotive, however, is an entirely new problem.

As yet, comparatively little has been done in the improvement of the locomotive in this country in the direction of superior economy and efficiency. In Europe the high price of coal has led to care in design and in operation of locomotives which is unknown here. The French are a generation in advance of us in locomotive operation. In France, locomotive engineers use devices such as double valve gears and variable exhaust nozzles, which we do not intrust to our engineers and firemen. In England, the small number of locomotive failures on the road is a revelation to any one who studies them from our standpoint. In England, the locomotive is given a fair chance by receiving fair treatment, yet it probably does not cost more in the end. We certainly have much to learn from across the water, and while what we may learn is not so much in practice as in method, it is none the less important. That which we most need to learn from England is the value of appreciation of the locomotive and locomotive men. This will be learned and well learned, probably, in the near future; of this we may feel sure. We may safely count that when those who are now students are ready to be leaders of mechanical departments of our railroads, the position of the department head will have become an enviable one. There is no field of mechanical work so full of opportunity as this, and much depends upon those who are now fitting themselves for the leadership of to-morrow. These leaders may now be in the ranks; they may be in the colleges, but wherever they are their preparation must be thorough, for their work is to be great and it will grow to be still greater.

The idea of the importance of the mechanical problem, when demonstrated on a large scale, is suggested by the fact that on January 1, 1906, a combination of fifty-four railroads, controlled by the Vanderbilt interests, became known as "New York Central Lines." All cars, stations, locomotives, and all the office stationery used in transacting the business of these fifty-four roads will bear this name. This enormous combination of responsibilities is not as impressive in any other of its phases as it is in the matter of the motive power responsibilities. The question of design, of construction, of locomotives, of shops, and many other questions, which are comparatively small on the individual roads of this combination, now become great because of the effect of the practice in one portion of the system upon that in another. It is easily understood that such an aggregation of interests renders it necessary to prepare, through careful study, for every change in practice. The design of shops cannot be made without most thorough and careful consideration of practice in other parts of the system, made with the view of adopting the best in every detail, and the same applies with even more force in the case of locomotives. All this points to the necessity for very high authority to administer properly these responsibilities. In this discussion, only the high points are touched upon, many others being unmentioned because of the lack of time.

There seems to be no need of arguing at this time in favor of placing full and complete authority for such important problems in the hands of an official who stands immediately next to the throne. This, when done, will mean much to American railroads.

During the last ten years, motive power progress has been rapid, because of the change in operating methods brought about by the large train unit. This has brought advances in weight and power which are startling, and the roads are not too well equipped with either physical facilities or men. Some radical changes are necessary.

The "roundhouse foreman" as a designation of position has become outgrown, and the men required for the responsibilities of large and busy roundhouses cannot much longer be called foremen. They must be master mechanics, or the equivalent, because these positions have become more vitally important in the conduct of the railroad. The time has come for entirely separating shop and road responsibilities of subordinate officials. The larger shops require shop superintendents, and the conditions requiring master mechanics to look after enginemen, firemen, roundhouse forces, and the shops, as a combination, passed away some years ago. Motive power work is divided into three distinct fields: First, the shop problem. Second, the locomotive operation problem, including roundhouse service. Third, mechanical engineering.

To be successful in either of these, wide experience is necessary. It is into the engineering branch that technical school graduates are most likely to drift, the work being agreeable and being very closely allied to the student's work at school.

Without in any way reflecting upon the opportunities offered in the line of mechanical engineering work, it should be said that experience, either in the shops or in the roundhouse, is important for a young man who is to succeed. It seems desirable positively to recommend young men to delay entering the engineering work until they have had experience in one or both of the other branches. If they are by temperament and ability qualified for either shop or road administration, they will learn this fact most easily and quickly in connection with the actual work, and if they are better fitted for engineering problems, they will be better able to handle them later on, because of the road or shop experience. It seems, in general, desirable for most young men to avoid the drafting room immediately on completion of their college work, and it is believed that in this most railroad officials will agree.

A words seems to be needed as to progress. In studying the careers of successful men, a prominent fact is developed, which seems specially applicable to a successful railroad man. Those who have really advanced most rapidly and have risen highest have usually advanced slowly during the first dozen years. It is believed that an attractive future has been pictured for those who prepare and equip themselves in the right way to carry the mechanical railroad burden of the future. It most assuredly will pay to prepare thoroughly and well, for those who do this are sure to be greeted with most brilliant opportunities. In order to prepare thoroughly and well, however, years of experience are required.

The railroads themselves have not done as much as they might to provide the leadership talent which is so well known to be required for the future. It is, in fact, on many roads, left for the young men who now enter the service to correct this, and they can do so by thoroughly preparing for their work.

For young men to succeed, it is merely necessary to "make good." Every railroad official is looking for young men who may be trusted to do things. The official does not need to be told who can do them. A young man makes his record by his work itself. He should seek opportunities to do things that somebody wants done and in this way will become sufficiently conspicuous to attract attention. Of these opportunities, motive power work is full to overflowing.

The Commission on the French Navy has approved almost unanimously the building programme for 1906, which includes the construction of six new battleships.

DEVELOPMENT OF THE MARINE STEAM TURBINE.*

By HON. C. A. PARSONS and R. J. WALKER.

DURING the last few years the steam turbine has formed the subject of many papers read before various leading institutions, and its different applications have often been referred to. It is hardly within the scope of this paper to deal in detail with the earlier experiments and trials which have led up to the present satisfactory position of the turbine. It may be of interest, however, to briefly describe the various steps that have been made from time to time in the development.

In 1884 the first Parsons compound steam turbine

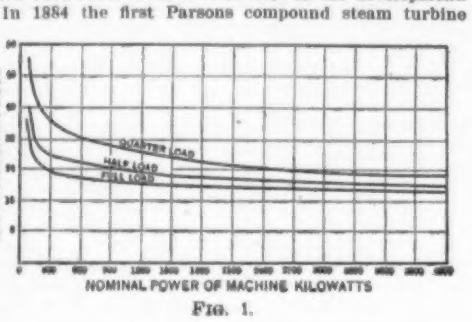


FIG. 1.

engine was built, and was applied to the driving of a dynamo. This engine was designed for 10 horse-power, with a modified high-speed dynamo, and for a working speed of 18,000 revolutions per minute. It ran for some years, doing useful work, and is now in South Kensington Museum. Subsequently, efforts were made toward the construction of engines of larger size, which resulted, in the year 1888, in several turbo-alternators of 120 horse-power being supplied for the generation of current in electric light stations, and at that period the total horse-power of turbines at work reached in the aggregate about 4,000, all of which were of the parallel flow type and non-condensing.

In 1892 the steam turbine was first adapted to work in conjunction with a condenser. This engine was capable of developing 200 horse-power at a speed of revolution of 4,800 per minute, and drove an alternator of 150-kilowatt output. It was tested by Prof. Ewing, F.R.S., and the result of the test showed a consumption of steam of 27 pounds per kilowatt hour, which is equivalent to about 16 pounds per I.H.P., with steam moderately superheated, and a vacuum of 28 inches. Since then, various improvements have been made, until at the present time the steam turbine is generally recognized to be an efficient and practical engine, which, in the larger sizes, has attained a high degree of economy in steam.

The following table shows the advance made in sizes and increased economy in steam consumption as applied for electrical purposes:

Date.	Capacity, Kilowatts	Steam per Kilowatt Hours, Lbs	Vacuum, Inches.	Superheat, Deg. F.	Steam Pressure per Square Inch, Lbs.
1887.......	75	50.00	....	....	120
1892.......	100	27.00	27	50	....
1898.......	1250	18.81	28	180	130
1901......	1000	17.30	27	198	150
1902	3000	14.74	27	235	138
1904.......	4000	15.40	28.7	150	2 0

Superheating of the steam has been adopted in the case of land turbines, and it has been found by experiments that for every 10 deg. F. of superheat, the steam consumption is reduced by about 1 per cent.

* Paper before the Engineering Congress at the Olympia Engineering Exhibition, London.

Fig. 1, which is based upon a large number of tests, shows the steam consumption of different sized plants per kilowatt-hour without superheating, from which it will be noted that the efficiency increases steadily as the size grows larger.

Turbine engines are also used for generating electrical current for the transmission of power, the working of electric tramways, railways, electric pumping, coaling, and similar purposes. They are also used for coupling direct to fans, and driving them for producing forced and induced draft for general ventilating purposes; also for driving centrifugal and screw pumps, and also for the more important work of driving blowers for supplying air under pressure, for blast furnaces and other purposes.

Land turbines have been very largely adopted in the past few years for the generating of electricity, judging from the fact that these machines are running in England in the power stations of some forty corporations and of twenty-five public electric supply companies. One of the largest power stations in England, now approaching completion, contains two units of 3,000 horse-power and six units of 6,000 horse-power each. The total horse-power of turbines of the Parsons type delivered and on order, including turbines at work and under construction by licenses on the Continent and in the United States at the present time, for land purposes is nearly 2,000,000. The installations now on order include units of upward of 10,000 horse-power.

The application of the steam turbine to the propulsion of ships has attracted a great deal of attention in the shipbuilding world within the last few years.

It was not until the year 1894 that the idea of propelling a vessel by means of a steam turbine was put into practical form. The "Turbinia," as is now generally known, was the first vessel to be fitted with turbine engines, and between the years 1894 and 1898 many experiments were made with the "Turbinia," necessitating radical changes in the design and arrangement of the machinery. The first engine which was tried was of the radial flow type, giving about 1,500 horse-power to a single screw. The results, however, were far from satisfactory, a speed of only 18 knots being obtained. Several different propellers were tested with this engine, and the results compared with the power registered by a dynamometer showed in every case a very low propeller efficiency. The original turbine engine was removed, and the engines finally adopted consisted of three turbines in series; high-pressure, intermediate-pressure, and low-pressure, each driving a separate shaft, with three propellers on each shaft. A reversing turbine was coupled with the low-pressure turbine to the central shaft. Very exhaustive trials were carried out by Prof. Ewing in 1897. A full account of these trials will be found in the Transactions of the Institution of Naval Architects, vol. xiv. (1903).

Following the success of the "Turbinia," the torpedo boat destroyers "Viper" and "Cobra" were built and fitted with turbine machinery for the Royal Navy, and achieved remarkable speeds, the "Viper" taking the position of being the fastest vessel in the world, having attained the phenomenal speed of 36.88 knots. Unfortunately, however, the "Viper" ran on the rocks of the Channel Islands in a fog, and ultimately became a total wreck. The "Cobra" foundered in a storm. Thus, after two or three years of hard work, the "Turbinia" was the only vessel afloat fitted with turbine engines.

About this period very great difficulty was experienced in endeavoring to induce railway companies and owners of mercantile vessels to build a turbine boat. Each company appeared anxious that some one else should make the first experiment.

The marine turbine was first adopted for commercial purposes in the Clyde steamer "King Edward," to the order of Capt. Williamson, in the summer of 1901 successful was this vessel during the first season's ning on the Clyde (the year of the great exhibition Glasgow), that an order was placed for a second vessel, "Queen Alexandra," and the performance of these two vessels running on the Firth of Clyde demonstrated the commercial advantages accruing from the adoption of the turbine system. Other vessels quickly followed the "King Edward" and "Queen Alexandra," until there are at the present time thirty-one turbine

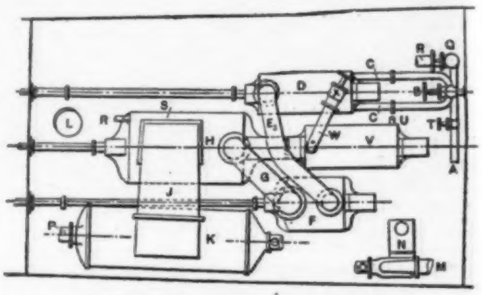


FIG. 3.—ANOTHER THREE-SHAFT ARRANGEMENT.

vessels in service for commercial purposes, representing a total of about 105,000 gross tonnage and 235,000 indicated horse-power.

The following table will perhaps best represent the various steps in the adoption of the turbine engine for commercial purposes:

Name of Vessel and Owners.	Dimensions.	Gross Tonnage.	Approx. I. H. P.	Year Built.
"King Edward," Turbine Steamers, Ltd.	250x30x17¾	562	3,500	1901
"The Queen," S. E. & Chat. Ry.Co	310x40x25	1,676	7,500	1903
"Virginian," Allan Line.	520x60x41	10,754	12,000	1904
"Carmania," Cunard Line	678x72x52	19,524	21,000	1905
"Lusitania," Cunard Line	785x88x60½	32,500	70,000	1906

As regards war vessels, the destroyers "Velox" and "Eden" were the next vessels following the "Viper" to be built for the British Admiralty. These two vessels were fitted with additional engines for obtaining economical results when cruising at low speeds. The next vessel to be fitted with turbines for the British Admiralty was the third-class cruiser "Amethyst." This vessel was also fitted with cruising turbines, and the results of the trials, as compared with sister vessels ordered at the same time as the "Amethyst," and of the same dimensions and lines, but fitted with reciprocating engines, demonstrated the economy of the Parsons marine turbine as fitted in this class of vessel, and more especially at the higher powers.

The battleship "Dreadnought" is one of the latest war vessels to be fitted with turbine engines. This vessel's turbines, which were manufactured by the Parsons Marine Steam Turbine Company, Limited, at the Turbinia Works, have now been installed, and the vessel is being prepared for trials. Particulars are given in the Memorandum of the Navy Programme of new construction, of the various war vessels which are at the present time being built, some of which are now nearing completion.

Comparisons of the earning powers of turbine vessels have been made from time to time with similar vessels on the same respective routes, which have been found to be favorable to the turbine, and in some cases the saving in coal is very considerable. A full account of these comparisons will be found in the Transactions of the Institution of Civil Engineers—"The Steam Turbine," by the Hon. C. A. Parsons and G. Steney—and in the Transactions of the Liverpool Engineering Society—"Progress made in the Application of the Parsons Turbine to Marine Propulsion," by R. J. Walker.

By the courtesy of M. Pierrard, of the Belgian government, particulars are just to hand of the first season's running of the turbine steamer "Princesse Elisabeth" on the Ostend and Dover service, and are given in the following table, along with the particulars of similar vessels on the same service, but fitted with paddle engines:

	Princesse Elisabeth.	Princesse Clementine	Marie Henriette.	Leopold II.
Length between perpendiculars........	104.85 m.	103.70 m.	103 70 m.	103.70 m.
Breadth...............	12.192 m.	11.58 m	11.58 m.	11.58 m.
Mean draft....	2.93 m.	2.85 m.	2.82 m.	2.82 m.
Displacement in metric tons........ .. .	2,005	1,853	1 847	1,829
Registered tons......	1,747	1,474	1,450	1,375
Type of engines......	turbines	compound	compound	compound
Speed on trial, knots.	24	22.187	22.2	22
Date of construction	1905	1896	1893	1893

In the year 1905 the mean consumption of coal per single trip and the mean time per trip from Ostend to Dover and *vice versa*, of the four preceding vessels, were as follows:

	P. E.	P. C.	M. H.	L. II.
Total number of trips.....	82.00	278.00	278.00	232.00
Mean duration of trips, minutes...	187 00	217.00	212.00	227.00
Mean consumption per trip, tons	23.01	24.05	23.82	24.30

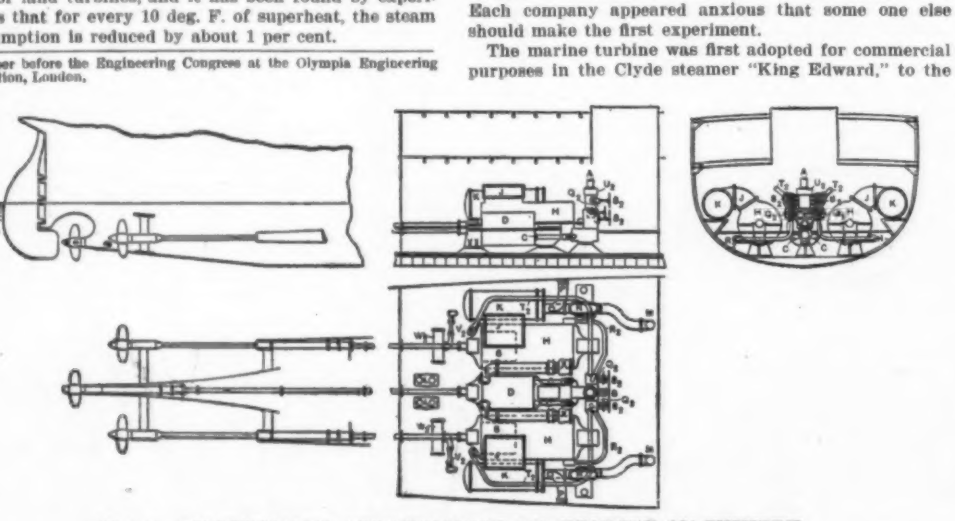


FIG. 2.—THREE-SHAFT ARRANGEMENT OF TURBINE MACHINERY.

A Steam from Boilers.
B Main Regulator Valve.
C Steam to High Pressure Turbine.
D High Pressure Turbine.
E Exhaust from H. P. Turbine to Automatic Closing Valve.
E_2 Exhaust from H. P. Turbine to I. P. Turbine.
E_4 Exhaust from H. P. Turbine to L. P. Turbine.
F Intermediate Pressure Turbine.
G Exhaust from I. P. Turbine to L. P. Turbine.
H Low Pressure Turbine.
J Exhaust to Condenser.
K Condenser.
L Air Pump.
M Main Inlet to Circulating Pump.
M_4 Steam to H. P. Astern Turbine.
N Circulating Pump.
N_4 High Pressure Astern Turbine.
O Circulating Discharge to Condenser.
O_4 Exhaust from H. P. Astern Turbine to L. P. Astern Turbine.
P Condenser Discharge Overboard.
P_4 Low Pressure Astern Turbine.
Q Astern Regulator Valve.
Q_2 Maneuvering Valve, L. P. Ahead.
Q_4 Regulator Valve to H. P. Cruising Turbine.
R Steam to Astern Turbine.
R_2 Steam to L. P. Ahead Turbine.
R_4 Steam to H. P. Cruising Turbine.
S Astern Turbine.
S_2 Maneuvering Valve, L. P. Astern.
S_4 High Pressure Cruising Turbine.
T Cruising Regulator Valve.
T_2 Steam to Low Pressure Astern.
T_4 Exhaust from H. P. Cruising Turbine to Self-Closing Valve.
U Steam to Cruising Turbine.
U_2 Governor Valve.
V Cruising Turbine.
V_2 Vacuum Augmentor.
V_4 I. P. Cruising Turbine.
W Exhaust from Cruising Turbine to Automatic Closing Valve.
W_2 Vacuum Augmentor Condenser.
X Automatic Closing Valve.
Y Direct Steam Regulator Valve to I. P. Cruising Turbine.
Z Direct Steam to I.P. Crusing Turbine.
a Exhaust from H. P. Cruising Turbine to Self-closing Valve, when Engine Rooms are Independent.
b Self-closing Valve.

References are to Figs. 2, 3 and 4.

For the first six months of the year 1906 the corresponding results were the following:

	P. E.	P. C.	M. H.	L. H.
Total number of trips	134 00	132.00	106 00	44.00
Mean duration of trips, minutes	185.00	210.00	206 00	202.00
Mean consumption per trip tons	22.71	23 22	24.27	24.87

	Turbine Boat.	Mean Result Paddle Steamers.
Total number of trips	216.00	1,070
Mean duration of trip, mins.	186.00	215
Mean consumption per trip tons	24.06	24

From the above table, it will be seen that the turbine boat does the passage in about 15 per cent less time than the paddle steamers, on the same coal consumption. To reduce the turbine boat to the displacement and speed of the paddle boats, and assuming that the indicated horse-power varies as the cube of the speed, the mean consumption of the "Princesse Elisabeth" would be about 17 tons, as against 24 tons in the paddle boats, thereby showing a saving of over 25 per cent.

The following mercantile vessels have been completed and placed on service this year:

The pleasure and mail steamer "Rewa" for the British India Steam Navigation Company, Ltd., of 455 by 56 feet and 16½ knots speed; the Clyde passenger steamer "Duchess of Argyll," for the Caledonian Steam Packet Company, of 250 by 30 feet and 20 knots speed; the Thames passenger steamer "Kingfisher" for the General Steam Navigation Company, of 275 by 32 feet and 20 knots speed. The three cross-channel steamers for the Great Western Railway Company's new route, Fishguard to Rosslare, viz., "St. David," "St. Patrick," and "St. George," of 350 by 41 by 13½ feet and 22½ knots speed; the cross-channel steamer "Viper" for Messrs. G. & J. Burns, of 315 by 39½ by 12 feet and 21¾ knots speed; and another Clyde passenger steamer, the "Atalanta," for the Glasgow and South Western Railway Company, of 210 by 27 by 10½ feet, and 17½ knots speed. In addition to the above, the two Great Central Railway steamers are nearing completion, and will, it is anticipated, be put on service this year, and the Khedival yacht "Mahroussa," which has been re-engined by Messrs. A. & J. Inglis, has run her trials, and a speed of 17½ knots was attained.

In addition to the large number of war vessels that are now being built and fitted with turbine machinery by some eight of the Parsons Marine Company's licenses, and also in addition to the two express Cunarders by Messrs. J. Brown & Co. and Messrs. Swan, Hunter & Wigham Richardson, Ltd., and the Wallsend Slipway & Engineering Company, the following mercantile orders are in hand: Two large ocean-going liners by the Fairfield Shipbuilding & Engineering Company; two cross-channel steamers for the South Eastern & Chatham Railway, similar to the "Onward" and "Invicta"; and a further steamer for the Union Steamship Company, of New Zealand, by Messrs. Denny; two large sets of turbine engines for shipment to Japan by the Turbinia Company, at Wallsend, and the Royal yacht, building by Messrs. Inglis, the turbine engines for which are being manufactured at the Turbinia Works, Wallsend, representing a total horsepower of work in hand of about 500,000.

Although the turbine itself has been described in various publications which are now being issued, it may be of interest to some of the members to briefly describe the principle of the Parsons turbine, and to mention a few points incidental to the application of the turbine system to different classes of vessels.

In regard to the arrangement of turbines, this depends partly on the condition of service, and the various classes of vessels require, more or less, to be taken upon their own merits. The arrangement which has been almost universally adopted in the mercantile marine is that of dividing the power equally over three shafts, viz., a high-pressure on the center shaft, exhausting into two low-pressure turbines, one on each side of the vessel. Fig. 2 shows a three-shaft arrangement of machinery. In such a case the high-pressure turbine is made suitable for an expansion ratio of about five, and the low-pressure for twenty-five. The turbines are of the parallel flow type, the general course of the steam through them being parallel to the axis.

Each turbine consists of a number of rings of blades or vanes mounted on a drum or rotor. This rotor is inclosed within a cylindrical case, upon which rings of blades are also fitted. The rings of blades are alternately fixed and moving, that is to say, the blades in the cylinder are stationary or guide blades, while the blades fitted on the drum are moving blades. The diameter of the drum is less than that of the cylindrical case, and thus an annulus is left between the two, which is occupied by the blades. Steam issuing from the boilers flows through the first row of fixed or guide blades on the cylinder; it then, in jets of moderate velocity, impinges on the moving blades, and imparts to them a rotary motion, this process being repeated on each successive ring of fixed and moving blades throughout the turbine.

As the steam passes from ring to ring it falls in pressure and increases in volume, and to meet this expansion the blades are increased in height by steps. The area of the steam passage through the blades thus gradually increases from one end of the turbine to the other, to correspond to the expansion in volume of the steam for the range of pressures from beginning to the end of the turbine.

The turbine shaft is coupled to the propeller shafting, and the thrust of the propeller is steam borne by the following arrangement:

Forward of the steam inlet a dummy piston is fitted, of reduced diameter to that of the main drum. A large number of small grooves are turned in this dummy piston, into which fit corresponding fixed brass rings, which are bedded into the dummy casing, forming steam baffles. The steam presses aft on the blades and on the annular part of the drum forming the step between the drum and the dummy piston, and the sum of

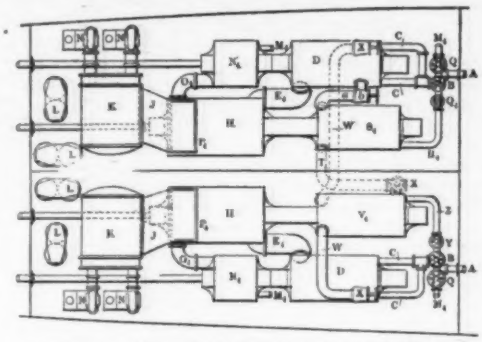


FIG. 4.—FOUR-SHAFT ARRANGEMENT.

these pressures balances the thrust of the propeller. To meet any unbalanced thrust, such as is set up when steam is turned on or off suddenly, and to maintain the true longitudinal alignment of the rotors, a small thrust block is provided at the forward end of the bearing. Where the turbine shaft passes through the casing, steam-packed glands are fitted. These glands consist of a number of rings or strips arranged in series, and designed to obtain a gradual rise or fall in pressure from the inner or steam end to the outer or atmospheric end of the gland. Valves are fitted to these glands to regulate the pressures, and to insure against leakage of air inward. All the main bearings are under oil pressure, and the oil is discharged from the pump at a pressure of from 8 to 10 pounds, or at such a pressure as to insure the efficient lubrication of all bearings.

In the exhaust casing of each of the low-pressure turbines a reversing turbine is fitted.

By means of suitable valves when maneuvering, the low-pressure and astern turbines on each side of the vessel are capable of being worked ahead or astern as required, independently of the high-pressure turbine, the latter, under such conditions, running idly in a vacuum. By this arrangement, the vessel has all the maneuvering qualities of a twin-screw vessel.

In torpedo boats, a similar arrangement is adopted as in the "Turbinia," viz., three in series, Fig. 3, with one astern on the center shaft only. This arrangement permits of a reduced weight being obtained as compared with the high-pressure and two low-pressures in parallel for equal efficiency.

In very large powers, it is desirable to divide the power over four shafts (Fig. 4), thereby increasing the revolutions and reducing the size of the units. The four-shaft arrangement lends itself well to large war vessels, as two complete sets of engines are obtained, one high-pressure and one low-pressure with condensing plant in each engine room. A two-shaft arrangement was adopted in the yacht "Narcissus," which gave very good results; but for powers over 2,500 to 3,000 a two-shaft arrangement entails additional weight.

One of the chief difficulties which had to be contended with in applying the steam turbine to the propulsion of ships arose in connection with the propellers. It is desirable, for obvious reasons, that a turbine for a given efficiency should be designed to run at as high a rate of revolution as possible, consistent with propeller efficiency. The speed of turbines for land purposes is considerably higher than is permissible for marine purposes, where the speed of rotation is limited by considerations of propeller efficiency. The questions of design of propeller, and turbine dimensions, require to be considered independently, and also to arrive at the best compromise to meet the conditions required, i.e., as to weight, space, efficiency, and conditions of service. With a view of increasing the revolutions, the diameters of the propellers and pitch ratios are less than is usual in the case of ordinary reciprocating engines, the smaller diameter of propeller necessitating higher ratios of blade surface to disk area than hitherto attempted with ordinary propellers.

In some of the earlier vessels multiple propellers were tried, but subsequent experiments showed that single propellers on each shaft were preferable. The loss of efficiency which has been observed in some of the vessels fitted with multiple propellers appears to have been due partly to interference from the forward screws, and partly to cavitation. Although more light might yet be thrown on the question of high-speed propeller efficiency, a considerable amount of experience has now been obtained with turbine-driven propellers, which enables a close estimate to be made as to the efficiency which might be expected in a given design where reliable data as to horse-power necessary for the proposal in question can be obtained.

On account of the greater range of expansion dealt with in the turbine as compared with the reciprocating engine, a good vacuum is much more essential in the former than in the latter, and because of the importance of a high vacuum with the steam turbine, careful consideration requires to be given to the condensing plant. With a view of maintaining a high vacuum, a new apparatus has been introduced, to assist the ordinary air pump and condenser, known as the vacuum augmentor. The augmentor consists of a small steam jet placed in a contracted portion of a pipe, led from the bottom of the condenser. The jet draws air from the condenser, and delivers it to the air pump through a small auxiliary cooler. By this means the air is reduced to a negligible quantity. The vacuum augmentor has now been fitted in several vessels with very good results. As an illustration of the importance of high vacuum, Fig. 5 shows the energy of steam that can be utilized in a steam turbine, as compared with a reciprocating engine.

Another point which has often been referred to in connection with turbine machinery is the question of boiler pressure. The effect of differences of boiler pressure between 150 and 200 pounds is relatively smaller with turbines than with reciprocating engines, and it is very questionable, in the majority of cases, whether the saving in coal by the adoption of high boiler pressures would justify the increase. More especially is this the case in moderate speed vessels, where, to obtain reasonable propeller efficiency, a certain diameter of propeller is necessary, and the revolutions to correspond are moderately low. It is necessary to obtain a certain surface speed of turbine, as well as a certain number of rows of turbine blades, to obtain reasonable economy. The diameter of the turbine, therefore, becomes greater in proportion to the power, and the blade heights in the annulus between the drum and the casing are relatively shorter; this gives a relatively greater clearance loss. The clearance area is practically constant for a given diameter, so that with higher pressures and denser steam the loss through clearance space will be greater.

Another point which has been greatly discussed in connection with turbine machinery is the question of the method of measuring the horse-power developed by the turbine engines. As is now more or less generally known, it is not possible to indicate the power of the turbine as in the ordinary method of the indicator diagram of reciprocating engines. In the absence of any such method, it is found most convenient to take the estimated I.H.P. as the equivalent indicated horsepower which would be required with reciprocating engines for the particular class of vessel proposed. Messrs. W. Denny & Bros. have recently introduced a new dynamometer or torsion meter for obtaining the power transmitted by the shaft, the readings being obtained by the torsional deflection of a given calibrated length of the main shafting. This instrument has been used on several vessels, and appears to give very reliable results; and where facilities are at hand for obtaining the effective horse-power by means of tank experiments the shaft horse-power, together with the effective horse-power, form a very good basis for estimating propeller efficiency.

Other advantages incidental to the turbine might be cited, such as reduced weight of machinery, steadiness and smoothness of running, reduction in oil and stores, and absence of racing in a seaway, and other advantages which have brought the turbine to a commercial success.

The development of the marine turbine has taken place almost entirely in Great Britain. A few war vessels have been built in France and Germany. The reason that the Parsons marine turbine has made so little progress on the Continent in the past is probably due to the fact that in France and Germany rival turbine systems of local origin have been energetically exploited, inducing those responsible for the ordering

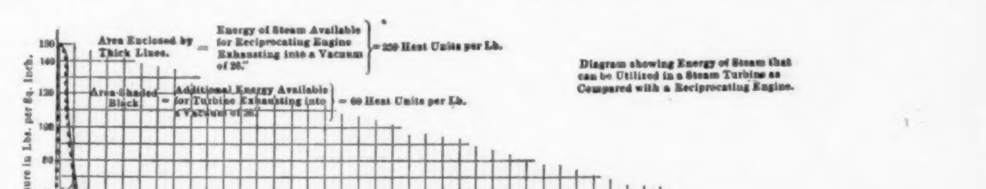


FIG. 5.

Vessel.	Length.	Beam.	Depth.	Tons.	Speed.
Steam yacht:					
Turbinia (a)	100	9	7	45*	34.5
Emerald (b)	198	28.7	18.5		15.
Lorena	253	33.3	20.3		18.01
Tarantula	152.5	15.3	8.8		25.36
Albion	240	34	20		15.
Narcissus	210	27.5			14.5
Mahroussa	400	42			17.5
Destroyer:					
Cobra	223.5	20.5	13.5		34.6
Viper (c)	210	21	12.5		36.88
Velox	210	21	12.5		27.12
Eden	220	23.5	13.8		26.23
River steamer:					
King Edward (d).....	250	30	17.8	562	20.48
Queen Alexandra (e)..	270	32	18.8		21.63
Duchess of Argyll....	230	30			20.
Kingfisher	275	32			20.
Channel steamer:					
The Queen (f).......	310	40	25	1,676	21.73
Brighton (g)	280	34	22		21.37
Princess Maud (h)...	300	40	24.5		20.66
Londonderry	330	42	25.3		22.29
Manxman (i)	330	43	18		23.
Viking (j)	350	42	16		23.53
Princesse Elisabeth(k)	344	40	23.2	1,747	24.03
Onward	310	40	25		22.53
Invicta	310	40	25		22.5
Dieppe (l)	284	34.7	22		21.5
St. David	350	41			22.5
St. Patrick	350	41			22.5
St. George	350	41			22.5
Viper (m)	315	39.5			21.75
Atalanta	210	27			17.5
Cruiser:					
Amethyst (n)	360	40		3,000*	23.63
Torpedo boat (French):					
293 (o)	130	14			26.2
Transatlantic Liner:					
Virginian (p)	520	60	41	10,630	19.11
Victorian (p)	520	60	41	10,630	18.75
Carmania (q)	678	72	52	19,524	20.
Ocean steamer:					
Loongana	300	43	16.5		20.15
Maheno (r)	400	50	38.5		16.5
Lhasa	275	44	25.5		18.09
Linga	275	44	25.5		18.05
Lama	275	44	25.5		18.
Lunka	275	44	25.5		18.
Rewa	455	56			16.5
Bingera	300	40	19		16.
Lake steamer:					
Turbinia (s)	250	33	20.8	1,100*	18.46

* Displacement.

See Marine Engineering (a) 6, June, 1897; 11, July, 1897; 14, Dec., 1897; 28, Feb., 1898; 26, March, 1898; 1, January, 1899. (b) 196, April, 1903; 317, June, 1903. (c) 213, November, 1899. (d) 395, September, 1901; 8, January, 1902. (e) 422, August, 1902. (f) 528, October, 1903. (g) 10, January, 1904. (h) 323, July, 1904. (i) 487, December, 1905. (j) 433, November, 1905. (k) 488, December, 1905. (l) 247, June, 1905. (n) 37, January, 1905. (o) 43, January, 1905. (p) 359, September, 1905. (q) 1, January, 1906. (r) 489, December, 1905. (s) 427, September, 1904. 5, January, 1905. (m) International Marine Engineering, 321, August, 1906.

of new vessels to defer the adoption of a new system until the claimants had results to show.

The Parsons turbine was introduced to the Continent by the small French torpedo boat "No. 293." This boat, ordered by the French navy as an experiment in the year 1903, has been in continual service for over two years without any breakdown or repair, and continues to give in practice the results obtained on trial. Naturally, so small a boat hardly demonstrates the results which might be expected from larger installations. The above-mentioned experimental torpedo boat is 130 by 14 feet, and of 95 tons displacement. She attained a speed of 26.2 knots. The arrangement of machinery is similar to that in the "Turbinia," three turbines in series.

In France, a mail and passenger boat is being built for the Marseilles and Algiers service of the Compagnie Generale Transatlantique. She is 378 by 43 feet, and is designed for a service speed of 20 knots. In the United States five passenger vessels are being built, and a scout cruiser of 24 knots speed for the government, to be fitted with Parsons turbines.

Reference to the table will show the vessels which have been engined in Great Britain with Parsons turbines up to the present date, representing a total horsepower actually completed of about 280,000. The total horse-power of marine turbine engines completed and on order with the Parsons Marine Company and their licensees is over 870,000.

DEVELOPMENT IN THE EXPLOSIVES ART IN THE UNITED STATES DURING THE LAST FIVE YEARS.*

By CHARLES E. MUNROE, Ph.D., Professor of Chemistry, George Washington University.

IN my report on the progress of the explosives industry of the United States made at Berlin, I was able to give statistical data from the census of manufactures for 1900, but though by law this census is now to be taken each fifth year, the returns for the census of 1905 are not yet reduced to such a condition that they may be cited. In lieu of this we have an estimate collected by an independent canvass, from which it appears that 346,841,891 pounds of explosives of all kinds were manufactured in the United States in 1904. As the total reported for 1900 was 215,980,719 pounds, we have a gain in about five years of 130,861,172 pounds, representing 62.27 per cent.

This estimate was made in connection with an investigation into the conditions of transportation of explosives. Owing to the peculiar form of government existing in the United States, the federal law is of the most general character and is practically limited to prohibiting, under penalty, the transportation of certain explosives in any vehicle carrying passengers. The separate States have power to make their own laws regulating this traffic, and many have done so, while a considerable number of cities have enacted special ordinances. But not all States or cities have made regulations, and there is a wide diversity in the laws and ordinances of the several States and cities. The railroads, being independent corporations, have made regulations which are equally diverse in character. Some of these railroads refuse to transport any explosives whatever; others transport only black powder; others accept explosives only on particular days; others accept high explosives only in carload lots. This confusion in laws, ordinances, and regulations perplexes the manufacturer, embarrasses the consumer, is expensive and dangerous.

Accidents have occurred from time to time in manufacture, storage, and transportation, and as they have attracted attention repeated efforts have been made to secure reasonable and uniform regulations by which to control transportation and reduce the chance of accidents. An accident during transportation, which occurred on the railroad near Harrisburg, was of unusual magnitude and attended with many fatalities, and this served to arouse public opinion to such an extent that a body representing the major number of the railroad corporations, and styled the American Railway Association, appointed a Committee on Transportation of Explosives and employed three experts in explosives to advise with them, with the result that a set of regulations embodying the best results of experience and adapted to our peculiar conditions were formulated, and in September last submitted to the railroads of the country for adoption. The prospect now is that these regulations will be very generally put into operation. Especial effort is being made to prevent secret shipment of explosives.

During the consideration of the various problems before the committee, it was deduced that taking the total output for the year as stated above, and a carload as 20,000 pounds, there was produced 17,342 carloads during the year, or a little over 47 full carloads per day, all of which is transported away from the works in which it is manufactured, and most of it by railroad. However, much of this is transported in less than carload lots, especially from central depositories or magazines. From observation and experience railroad officials estimate that the cars carrying small lots are five times as numerous as those carrying the full load, hence we have 330 cars per day loaded with explosives. It is estimated that on the average ten days are required in which to transport and deliver these consignments, therefore there will be each day on the railroads throughout the United States an average of 3,300 cars carrying explosives, and during the busy seasons and at special locations they will be especially numerous. The surprise is not that accidents do occur, but that they occur so infrequently. The inference is that notwithstanding the lack of regulations, the numerous employees to whose care this transportation has been intrusted have performed their duties in an intelligent and vigilant manner.

A marked change in the methods of conducting the explosives business to be noted is the union of interests of many of the larger manufacturers under the leadership of the famous Du Pont Company. By this means greater economies in manufacture are effected, while it has become possible to enter on a large scale into the manufacture of the raw materials, such as nitric, sulphuric, and mixed acids, which are used in the making of explosives, availing themselves of the contact process and other modern improvements in these arts. At the same time research laboratories on modern lines have been founded, and expert chemists and engineers employed to develop manufacture on scientific lines. Nevertheless, there are still many independent companies, and competition is keen. The United States government is especially concerned with the manufacture of military smokeless powder, and while it receives the major portion of its supplies from private manufacturers, it possesses two factories controlled by the Navy Department, and appropriations are asked from the present Congress for the erection of others to be under the control of the War Department.

A detail which has affected yields and costs in the dynamite industry is the introduction of ice machines for use in the manufacture of nitro-glycerine. By the use of artificial refrigeration the yield of nitro-glycerine from a given mass of acid is increased, the speed of nitration is increased, the danger attending nitration is decreased, and the use of second separators rendered unnecessary. Two methods of refrigeration may be used: (1) The direct expansion system, in which compressed ammonia is sent directly through the coils; and (2) the brine system, in which the ammonia is sent through the coils in a brine tank, and then the cooled brine is sent through the cooling coils in the nitrator or separator. The brine or indirect system is to be preferred, because in case of leakage in the nitrator the rise of temperature would be less from the escape of a given mass of calcium chloride brine than from the escape of the same mass of ammonia; leakage of the calcium chloride brine is less likely to occur than is that of the compressed and liquefied ammonia; less ammonia is required in the indirect than in the direct system, and the indirect system is a better one for discontinuous use.

The quantities of acids and glycerine and the composition of the mixed acids vary somewhat in practice, but the advantage of artificial refrigeration may be illustrated by a concrete example, in which the charge of mixed acid is 6,400 pounds and its composition is

H_2SO_4	61.50 per cent
HNO_3	34.50 per cent
H_2O	4.00 per cent

With such a charge using the approved method of nitration without refrigeration, 880 pounds of glycerine may be nitrated and 1,953.6 pounds of nitro-glycerine obtained, while when using artificial refrigeration 928 pounds of nitro-glycerine or an increased yield of 162.24 pounds will be obtained. With glycerine at 11 cents per pound and nitro-glycerine at 15 cents per pound, the increased profit from a single run is $19.05, or for four runs per day, which can be easily effected, a profit of $76.20. As a 30-ton machine can be easily installed for $12,000, and the cost of operation, including interest and 10 per cent depreciation, will not exceed $6,000 per year, there is a marked advantage in artificial refrigeration.

At the same time we are far from realizing the theoretical conditions of efficiency, for the charge of acid cited above is theoretically sufficient to nitrate 1,074.77 pounds of glycerine and to yield 2,651.31 pounds of nitro-glycerine, or 535.07 pounds more than is obtained by artificial refrigeration. I have, many years ago, advised my clients to thoroughly dry the air injected into the nitrator. Combined with refrigeration such dry air ought to enable us to approach more nearly to the theoretical yield, but I have as yet no data on this subject.

It is well known that at times the separation of the nitro-glycerine from the emulsion in the acid mixture in which it is formed is extremely slow. Dr. Charles L. Reese alleges that this is due to the presence of silicon compounds, and he overcomes this difficulty by the addition of a fraction of a per cent of sodium fluoride before nitration, thereby forming silicon fluoride, which is eliminated by volatilization.

For the census year 1900 the smokeless powder of all kinds made in the United States amounted to but 3,053,126 pounds, having a value of $1,716,101. While, as stated above, no figures are yet available for 1905, yet it is believed that there has been a great increase in production of both military and sporting smokeless powders. A notable change in practice has been in the abandonment of the nitro-glycerine nitro-cellulose powder by the army and the adoption of a straight nitro-cellulose powder of definite nitrogen content, thus bringing their practice into conformity with that of the navy. In fact, the continued tendency in military powders is to approach more closely to the principle set forth by the writer many years ago as governing the ideal smokeless powder, viz., "it should be composed of a single chemical substance in a state of chemical purity."

The progress in smokeless sporting powder has been characterized by the adoption of a small-grained nitrocellulose powder, which is gelatinized and then hardened throughout, in place of the grain which has heretofore been in pretty general use, and which was superficially gelatinized and hardened. The manufacture of such powder is carried out in a stationary vertical vessel of copper which has cone-shaped ends. Around the lower end is a steam jacket, by which the contents of the vessel may be heated. A rotatable shaft extends downward through a stuffing box in the top of the vessel, or still, to a point near its bottom, and carries six arms extending across it, each arm being attached at its central point to the shaft and at points on the shaft about eight inches apart, and the ends of the arms reach nearly to the wall of the still. Five of the bars are square in cross-section and about one inch thick; the sixth bar, which is the upper one, is flattened out so as to form paddles, which slant in the direction of motion of the shaft in such a way as to smooth down the surface of the liquid which is placed in the still.

An orifice at the bottom of the still having been first closed, the vertical shaft carrying its horizontal stirrers is set in rotation, and continued in rotation during the whole of the process at a speed sufficient to maintain the particles of guncotton in mechanical suspension in the water, when the guncotton and water are introduced into the still as hereinafter described.

Water in which five per cent of barium nitrate and two per cent of saltpeter have been dissolved is then pumped into the still, through a pipe provided for this purpose, until the still has been partly filled. Finely-pulped wet guncotton is then thrown into the still through an opening in the side of its upper part, this guncotton not having been as yet subjected to the action of any solvent. More water in which barium nitrate and saltpeter have been dissolved is then pumped into the still until the surface of the liquid in the still is about on a level with the upper stirrer blades on the vertical shaft. The opening through which the guncotton was inserted is now closed, and a previously-formed emulsion of from 25 to 50 per cent of amyl acetate in water containing barium nitrate and saltpeter in solution is pumped into the still.

The material now begins to granulate, and the progress of the granulation is observed by withdrawing a little of the mixture through a small orifice near the bottom of the still; and when granulation has been effected throughout the mass, which is within about five minutes after the introduction of the emulsion into the still was begun, steam is turned into the jacket surrounding the lower portion of the still. The heating due to the steam is continued for a period of five or six hours, and during this time the amyl acetate is distilled and passes over, with the vapors from the heated water, into a reservoir where the water is separated from it.

After the amyl acetate is thus removed a gate valve in the bottom of the still is opened, and the mixture of water and granulated powder is discharged from the still into a draining tank. After draining it is dried, sized, blended, and packed. The strength and the amount of the emulsion used depend upon the amount and quality of the guncotton, and the best proportions are ascertained by experience. The length of time the heating is maintained depends upon the amount of amyl acetate used and the temperature of the steam in the steam jacket.

The still may measure about 6 feet 3 inches from its bottom to the upper stirrer blades, and about 5 feet in diameter in its cylindrical portion. In such a

* Read at Sixth International Congress of Applied Chemistry in Rome, April 13, 1906.

vessel the usual charge of guncotton is 405 pounds, to which is added the dust or very small grains from previous granulations, making a total charge of upward of 700 pounds. The finished powder is colored to suit the taste of the consumers.

Although active efforts have been made to introduce safety explosives into commercial use in the United States, and though joveite, which is an excellent explosive of this type, has received the highest encomiums for safety and efficiency from engineers and explosive experts who have observed it in use under all sorts of conditions for over ten years, yet the fact that slightly more care must be taken in loading and priming shot holes to insure explosion where a safety explosive is used than when dynamite is employed, and that strong caps must be used, has been sufficient to prejudice miners against the use of safety explosives; notwithstanding that they commend themselves to the mine owners. The chief thought of the miner seems to be to do his allotted task in the quickest manner and with the least effort.

THE TWENTIETH CENTURY PEN.*

By W. R. STEWART.

THE pen which seemed mightier than the sword to Lord Lytton was a very simple affair to make, compared with that which the writer of the present day employs. Although, to the eye, the ordinary steel pen of 1906 is not a particularly complicated instrument, yet no fewer than twenty distinct operations enter into its making. That the completed product can be sold at a retail price of about two-thirds of a cent a pen is striking testimony to the delicate perfection of the machinery employed. To make a fountain pen no fewer than one hundred, and in some cases more operations are required. The gold nib alone represents sixty or seventy of these different processes.

It was not until 1800 that the first steel pen made in the United States pushed its tentative way across paper, guided by the hand of one Peregrine Williamson, a Baltimore jeweler. It was not until sixty years later that the first steel pens were manufactured by mechanical process in this country. There had been a few made in England as early as 1820, but they were far from being the flexible instrument they have since become, and their cost was excessively high.

During last year about two hundred and eighty-five million pens—steel, gold, and fountain, or stylographic—were manufactured in the United States. Fifty establishments were engaged in the pen industry in the United States last year, and the wholesale value of their products was somewhat in excess of two million dollars. About four thousand wage-earners, largely women, were employed in the different factories. Of the total production of pens, about 54 per cent were manufactured in the State of New York.

Of the three general varieties of pens now made, those of steel are, naturally, produced in by far the greatest number, contributing about 270,000,000 of the total production of 285,000,000 pens for the United States during 1905. In point of value however, the steel pens represented only $300,000, as against $820,000 worth of gold pens, and more than a million dollars' worth of fountain and stylographic pens.

Let us consider first the steel pen. Just who the real inventor of the steel pen was is unknown, the honor being claimed for both an Englishman and a Frenchman, as well as for the jeweler of Baltimore. The pens first produced by mechanical process in England consisted simply of a piece of steel formed into a tube and filed into shape by hand, the joint of the two edges forming the slit. The product was expensive and unsatisfactory, for the pen was hard and inflexible. By degrees presses were contrived for cutting, bending, and marking, and other machinery for cleaning and polishing.

The material now used for all kinds of steel pens is cast steel of the best quality, and as this has not yet been produced successfully in the United States, it is imported from England and Sweden. This steel is received at the pen factory in sheets of various lengths, widths, and thicknesses. It is there prepared for conversion into pens by a preliminary process of annealing (heating nearly to fluidity and then cooling slowly in order to render less brittle), polishing, and rolling. These operations need not be described, though that of rolling requires much care and skill, for the steel must be passed between successive rollers until reduced to a required thickness, which is usually the 1/160 of an inch. The variation of one-thousandth part of an inch in the thickness of the strip would seriously affect the flexibility of the pen. After emerging from the rollers, the strips are about three times their original length, and have a bright surface.

The process of forming and shaping the pen begins at this point, and in this work mostly women and girls are employed, on account of their greater dexterity of hand. A die and a punch are used to cut out the blank strips from which the pens are to be made. The die is set in a supporting frame or bolster, and is perforated by a hole the exact shape of the required blank. A punch, also of the exact shape of the blank, is attached to the bottom of the screw bolt of a press. One of the strips of steel is then introduced by the operator, using her left hand, at the back of the press, and the handle pulled toward her with the right hand. This causes the screw to descend, driving the punch into the bed and perforating the strip of steel, making a blank which falls through the opening in the die into a drawer underneath. This operation is repeated until the whole of the strip is perforated.

The next stage in the making of the pen is stamping, or marking it with whatever name or number it is to bear. This mark is cut upon a piece of steel, which is placed in the hammer of a stamp, the latter being operated by foot power. A handful of blanks is taken by the operator in the left hand, and a little train made of them between the thumb and finger. With the right hand the blanks then are placed, one after the other, in a guide upon the bed of the stamp, where the hammer forthwith falls upon it, giving it the impression cut on the punch. As many as twenty thousand pens can thus be stamped by a skillful operator in a day.

The small hole which terminates the slit in the finished pen and prevents it from spreading, as well as producing the elasticity required and causing the ink to attach itself to the pen, is next pierced. To do this a piercing punch and bed, made with great precision, are fixed in a screw press, to which an ingenious arrangement of guides has been attached. The blank is then placed in the proper position and the machinery manipulated so as to cause the screw to descend, driving the punch into the bed.

The blanks are now annealed so that they become pliable, and assume readily the various shapes into which they are to be made. A punch and die are again called into requisition, and the process which they perform in shaping the pen is called raising. After being given their curved form, the blanks are hardened by plunging in hot oil. They are next cleaned in sand and sawdust and tempered. The cleaning, or polishing, is accomplished by placing the pens in revolving barrels of sand or sawdust, and then grinding against a revolving emery wheel. The tempering is done by placing the pens in an iron cylinder, which is kept revolving over a charcoal fire until they are of the proper temper. This process is one of considerable delicacy, being regulated according to the color shown by the pens, which indicates the varying temperatures of the metal.

The last mechanical operation upon the pen is, perhaps, the most important. This is the slitting of the point, which is done by a specially constructed pair of cutters equal in delicacy to the cutting edge of a razor. These cutters consist of two oblong pieces of steel, about 1½ inches long, ⅜ inch thick, and 1¼ inches wide. One of the cutters is fixed in a press with a pair of guides screwed on either side, the other cutter being held by a bolster, to which is attached a small tool called a rest or table. The pen is placed by the operator on the table, the point pushed up toward the guide, and the upper cutter made to descend and meet the lower one, thus slitting the pen. A final burnishing, and possibly lacquering, completes the pen, the lacquer giving it a glossy appearance and preventing rust.

So much for the making of steel pens. But gold and fountain pens are being manufactured in constantly increasing proportion. Of the former, the chief virtue of which is that they possess a greater durability and flexibility than pens made of steel, there were produced in the United States about a million during last year.

To a watchmaker of Detroit belongs the distinction of having first commenced the manufacture of gold pens in this country, in 1835. The business, however, was soon moved to New York. Before 1835 several attempts had been made in England to make gold pens, but they had met with little success. At first the points of gold pens were protected by diamonds or rubies, alloyed gold being too soft to make a durable point. The discovery that the native alloy of iridium and osmium, one of the hardest and most refractory of all metallic alloys, could be used much more cheaply and more satisfactorily, revolutionized the industry. These iridium points are now imbedded in the gold, instead of being soldered on as was at first done.

Gold pens are made in a manner similar to steel pens, by rolling the metal into thin sheets and stamping out the blanks and shaping them with dies. The gold is melted and alloyed to about 16 karats fine. The blunt nib of the blank is notched at the end to receive the iridium, which is coated with a cream of borax which is ground in water. The imbedding of the iridium in the pen point is accomplished by a process of "sweating," which consists in melting the gold of which the pen is formed so that it unites solidly with the iridium. The blank is then passed between rollers which give it a gradually diminishing thickness from the point backward, the rolls having a small cavity in which the extreme end of the iridium nib is placed to prevent injury to it.

The most important process in the manufacture of the gold pen is the hammering of the nib, in order to stiffen it and render it springy or elastic. The slit is cut through the solid iridium by means of a thin copper wheel, after which it is extended up the pen itself, to the notch, with a saw. The pen is finished by polishing upon buff wheels.

Fountain pens—pens which have an ink barrel in the holder which supplies ink as required by means of an automatic feed—are the most modern and the highest type of art of the pen maker. They were not made in the United States until about 1880. A fountain pen may be said to consist of four pieces of hard rubber and an ordinary gold pen. The handle containing the ink reservoir is in two pieces, which are connected with a screw joint, which permits it to be taken apart readily for filling. The gold pen is held in the point section by a rubber ink feeder lying adjacent to it, to attract the ink from the reservoir. As the ink in the process of writing is withdrawn, air enters at the lower end of the holder and ascends in globules through the column of ink to fill the space left vacant. The fourth piece of rubber is the cap, which covers the pen to protect it from injury and to keep the ink from drying when not in use. A fountain pen usually holds ink enough for writing from 15,000 to 20,000 words without refilling.

The rubber which goes into the making of fountain pens is the best obtainable, coming chiefly from Para, Brazil, and reaching the pen factory in chunks as large as a man's head. It is there first torn apart, washed, and then allowed to dry for several months. After this it is rolled out, in shape like a sheet of iron, sprinkled and rolled in sulphur, then vulcanized and made ready for working. In this condition it is next rolled on steel cylinders, or mandrels, and placed in a steel heater for several hours. The metal rods are then withdrawn, leaving the empty cylinders, and the outside of the various parts are smoothed down with lathes, polished, and made to fit one another by skilled workmen.

The stylographic pen is a variety of fountain pen in which a blunt needle, which is incased in a sheath at the end of the holder, serves as a valve to release the ink when the point is pressed on the paper. There were about a million and a half of fountain and stylographic pens manufactured in the United States during 1905.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

PRESERVATION OF FOODS.*

VARIOUS methods have been employed from time to time for the preservation of foods, first for the purpose of transportation and second for use during times of scarcity. Long ago drying proved an effective method, since the germs of decomposition require moisture for their growth and development. For some foods it is still desirable. For example, sweet corn, when properly dried and carefully cooked, is more palatable than canned corn. Raisins and prunes are examples of dried fruits, which are very palatable and wholesome. The old-fashioned plan of preserving fruits by pickling in salt or vinegar or preserving in equal parts of sugar are all effective in keeping the fruit, but are unhealthful. The addition to the fruit of anything which will destroy or prevent growth of germ life, will most certainly prevent or retard digestion, for the ferments of the digestive juices are affected by precisely the same things that affect germ life. However, pickles and preserves may be eaten in small quantities by those of vigorous digestion without proving a great menace to the health. Much more to be condemned is the modern process of preserving by use of antiseptics, such as salicylic acid, which has been most generously used because it imparts no disagreeable flavor to the fruit and is detected with difficulty. It is, however, a very powerful drug and even when taken in small quantities produces burning in the stomach, affects the heart and occasions other organic disturbances.

All decay or fermentation of food substances is due to the action of germs. These microscopic organisms will cease to thrive under certain conditions. If fruit is kept in a cold, dry atmosphere, at about 40 deg. F., where currents of air are excluded, it may be preserved for a long time, since the germs of decomposition cannot grow rapidly in such an atmosphere. This method of keeping foods is known as refrigeration, and is commonly applied in every-day life where we bury fruit or vegetables in the ground or store them in a cool cellar. The boiling temperature continued for about thirty minutes will ordinarily destroy germ life. Hence boiling fruit and sealing in air-tight cans, where the germs present in the air cannot gain access, is an effective method of preservation, within the ability of every housewife. It has also the advantage of being eminently hygienic.

THE KEEPING QUALITIES OF FRUITS.

Fruits vary in keeping qualities. Those rich in acids are easily kept since the yeasts of fermentation do not grow readily in an acid solution. Tomatoes seldom spoil. The vegetables, peas, beets, asparagus, corn, etc., are difficult to keep, as they contain no acid and considerable sugar, yet they may be satisfactorily canned at home if the proper precautions are taken. Rhubarb contains enough oxalic acid to preserve it without cooking. Slice, put in a jar of cold boiled water, fasten the lid, and it will keep indefinitely. Gooseberries, if not too ripe, may be treated in the same way. It is needless to say that fruits which will keep in this way are not altogether wholesome. The pineapple is an exception to most fruits in that it contains an enzyme (an unorganized ferment) like pepsin, which has the power of digesting albuminoids, milk, meat and eggs. It also destroys the yeasts which are the cause of fermentation. When properly canned without sugar it keeps very well.

PREPARATION FOR CANNING.

Select self-sealing cans of some good variety. Of the many kinds on the market the screw-top jar is good and not expensive. The Economy jar, recently put on the market, is also good, though the necessity of buying new lids each time the jars are used is an appreciable expense. Some of the new screw-top jars are very defective. There may be dents around the top where the rubber is fitted to the jar or a rough edge at the top, making it very difficult and sometimes impossible to fit a lid to the jar. The first difficulty may sometimes be overcome by pressing the lid down at the edge to fit the jar, and the second may be removed by filing the edge of the jar with an ordinary file. Examine the jars before buying and reject those that are defective, since no dealer has a right to sell such jars at the same price as good ones. Always use

* Rocky Mountain Farming.

good rubbers. The red rubber rings at 10 cents per dozen are the best. They may usually be used a second time if they have not been cut or broken.

The proper preparation of jars and lids is absolutely essential to good results in fruit canning. See that the cans and covers are perfectly cleaned. The jars are not difficult to sterilize as the surface is smooth and gives little lodgment to germs. Scalding the jars in boiling water is sufficient in ordinary practice. The jar will not break if it is warmed before immersing in the boiling water. If fruit has spoiled in the bottles it is safer to sterilize by boiling thirty minutes in water. The porcelain lined lids offer many crevices for the lodgment of dirt and germs and must be sterilized by boiling in soap suds or a borax solution for half an hour, or baked in an oven at a temperature sufficient to scorch paper for two hours. Clean the rubber rings, and if new, wash in warm water in which is dissolved a little ammonia or soda to remove the disagreeable odor of new rubber. Test each jar to see if it is air-tight, with a good rubber and a close-fitting lid, by partly filling with water, screwing on the top and placing bottom upward on the table some time before using. If none of the water leaks out, the jars are safe to use.

SPECIAL MESSAGE OF THE PRESIDENT OF THE UNITED STATES CONCERNING THE PANAMA CANAL, COMMUNICATED TO THE TWO HOUSES OF CONGRESS ON DECEMBER 17, 1906.

In the month of November I visited the Isthmus of Panama, going over the Canal Zone with considerable care; and also visited the cities of Panama and Colon, which are not in the Zone or under the United States flag, but as to which the United States government, through its agents, exercises control for certain sanitary purposes.

The U. S. S. "Louisiana," on which I was, anchored off Colon about half past 2 on Wednesday afternoon, November 14. I came aboard her, after my stay on shore, at about half past 9 on Saturday evening, November 17. On Wednesday afternoon and evening I received the President of Panama and his suite, and saw members of the Canal Commission, and various other gentlemen, perfecting the arrangement for my visit, so that every hour that I was ashore could be employed to advantage. I was three days ashore—not a sufficient length of time to allow of an exhaustive investigation of the minutiæ of the work of any single department, still less to pass judgment on the engineering problems, but enough to enable me to get a clear idea of the salient features of the great work and of the progress that has been made as regards the sanitation of the Zone, Colon, and Panama, the caring for and housing of the employees, and the actual digging of the canal. The Zone is a narrow strip of land, and it can be inspected much as one can inspect 50 or 60 miles of a great railroad, at the point where it runs through mountains or overcomes other natural obstacles.

I chose the month of November for my visit partly because it is the rainiest month of the year, the month in which the work goes forward at the greatest disadvantage, and one of the two months which the medical department of the French Canal Company found most unhealthy.

Immediately after anchoring on the afternoon of Wednesday there was a violent storm of wind and rain. From that time we did not again see the sun until Saturday morning, the rain continuing almost steadily, but varying from a fine drizzle to a torrential downpour. During that time in fifteen minutes at Cristobal 1.05 inches of rain fell; from 1 to 3 A. M., November 16, 3.2 inches fell; for the twenty-four hours ending noon, November 16, 4.68 inches fell, and for the six days ending noon, November 16, 10.24 inches fell. The Chagres rose in flood to a greater height than it had attained during the last fifteen years, tearing out the track in one place. It would have been impossible to see the work going on under more unfavorable weather conditions. On Saturday, November 17, the sun shone now and then for a few minutes, although the day was generally overcast and there were heavy showers at intervals.

VIEW IN CULEBRA CUT.

The level at which the two men are standing is that reached by the French. The level at which the motor car stands is the present American level, 68 feet below.

On Thursday morning we landed at about half past seven and went slowly over the line of the Panama Railway, ending with an expedition in a tug at the Pacific entrance of the canal out to the islands where the dredging for the canal will cease. We took our dinner at one of the eating houses furnished by the Commission for the use of the government employees—no warning of our coming being given. I inspected the Ancon Hospital, going through various wards both for white patients and for colored patients. I inspected portions of the constabulary (Zone police), examining the men individually. I also examined certain of the schools and saw the school children, both white and colored, speaking with certain of the teachers. In the afternoon of this day, I was formally received in Panama by President Amador, who, together with the government and all of the people of Panama, treated me with the most considerate courtesy, for which I hereby extend my most earnest thanks. I was driven through Panama and in a public square was formally received and welcomed by the President and other members of the government; and in the evening I attended a dinner given by the President, and a reception, which was also a government function. I also drove through the streets of Panama for the purpose of observing what had been done. We slept at the Hotel Tivoli, at Ancon, which is on a hill directly outside of the city of Panama, but in the Zone.

THE PRESIDENT INSPECTING A STEAM SHOVEL NEAR THE ENTRANCE TO THE CULEBRA CUT.

THE PRESIDENT'S STORY OF HIS VISIT TO PANAMA.

On Friday morning we left the hotel at 7 o'clock and spent the entire day going through the Culebra cut—the spot in which most work will have to be done in any event. We watched the different steam shovels working; we saw the drilling and blasting; we saw many of the dirt trains (of the two different types used), both carrying the earth away from the steam shovels and depositing it on the dumps—some of the dumps being run out in the jungle merely to get rid of the earth, while in other cases they are being used for double tracking the railway, and in preparing to build the great dams. I visited many of the different villages, inspecting thoroughly many different buildings—the local receiving hospitals, the houses in which the unmarried white workmen live, those in which the unmarried colored workmen live; also the quarters of the white married employees and of the married colored employees; as well as the commissary stores, the bath houses, the water-closets, the cook sheds for the colored laborers, and the government canteens, or hotels, at which most of the white employees take their meals. I went through the machine shops. During the day I talked with scores of different men—superintendents and heads of departments, divisions, and bureaus; steam-shovel men, machinists, conductors, engineers, clerks, wives of the American employees, health officers, colored laborers, colored attendants, and managers of the commissary stores where food is sold to the colored laborers; wives of the colored employees who are married. In the evening I had an interview with the British consul, Mr. Mallet, a gentleman who for many years has well and honorably represented the British government on the Isthmus of Panama and who has a peculiar relation to our work because the bulk of the colored laborers come from the British West Indies. I also saw the French consul, Mr. Gey, a gentleman of equally long service and honorable record. I saw the lieutenants, the chief executive, and administrative officers under the engineering and sanitary departments. I also saw and had long talks with two deputations—one of machinists and one representing the railway men of the dirt trains—listening to what they had to say as to the rate of pay and various other matters and going over, as much in detail as possible, all the different questions they brought up. As to some matters I was able to meet their wishes; as to others, I felt that what they requested could not be done consistently with my duty to the United States government as a whole; as to yet others I reserved judgment.

On Saturday morning we started at 8 o'clock from the hotel. We went through the Culebra cut, stopping off to see the marines, and also to investigate certain towns—one, of white employees, as to which in certain respects complaint had been made to me; and another town where I wanted to see certain houses of the colored employees. We went over the site of the proposed Gatun dam, having on the first day inspected the sites of the proposed La Boca and Sosa dams. We went out on a little toy railway to the reservoir, which had been built to supply the people of Colon with water for their houses. There we took lunch at the engineers' mess. We then went through the stores and shops of Cristobal, inspecting carefully the houses of both the white and colored employees, married and unmarried, together with the other buildings. We then went to Colon and saw the fire department at

work; in four minutes from the signal the engines had come down to Front Street, and twenty-one 2½-inch hose pipes were raising streams of water about 75 feet high. We rode about Colon, through the various streets, paved, unpaved, and in process of paving, looking at the ditches, sewers, curbing, and the lights. I then went over the Colon hospital in order to compare

MESS HALL AT CULEBRA.

In this hall men are permitted to eat without their coats. Another room is reserved for those who, more conventional in their tastes, prefer not to eat in their shirt sleeves.

it with the temporary town or field receiving hospitals which I had already seen and inspected. I also inspected some of the dwellings of the employees. In the evening I attended a reception given by the American employees on the Isthmus which took place on one of the docks in Colon, and from there went aboard the "Louisiana."

Each day from twelve to eighteen hours were spent in going over and inspecting all there was to be seen, and in examining various employees. Throughout my trip I was accompanied by the Surgeon-General of the Navy, Dr. Rixey; by the chairman of the Isthmian Canal Commission, Mr. Shonts; by Chief Engineer Stevens; by Dr. Gorgas, the chief sanitary officer of the Commission; by Mr. Bishop, the secretary of the Commission; by Mr. Ripley, the Principal Assistant Engineer; by Mr. Jackson Smith, who has had practical charge of collecting and handling the laboring force; by Mr. Bierd, general manager of the railway, and by Mr. Rogers, the general counsel of the Commission; and many other officials joined us from time to time.

At the outset I wish to pay a tribute to the amount of work done by the French Canal Company under very difficult circumstances. Many of the buildings they put up were excellent and are still in use, though, naturally, the houses are now getting out of repair and are being used as dwellings only until other houses can be built, and much of the work they did in the Culebra cut, and some of the work they did in digging has been of direct and real benefit. This country has never made a better investment than the $40,000,000 which it paid to the French company for work and betterments, including especially the Panama Railroad.

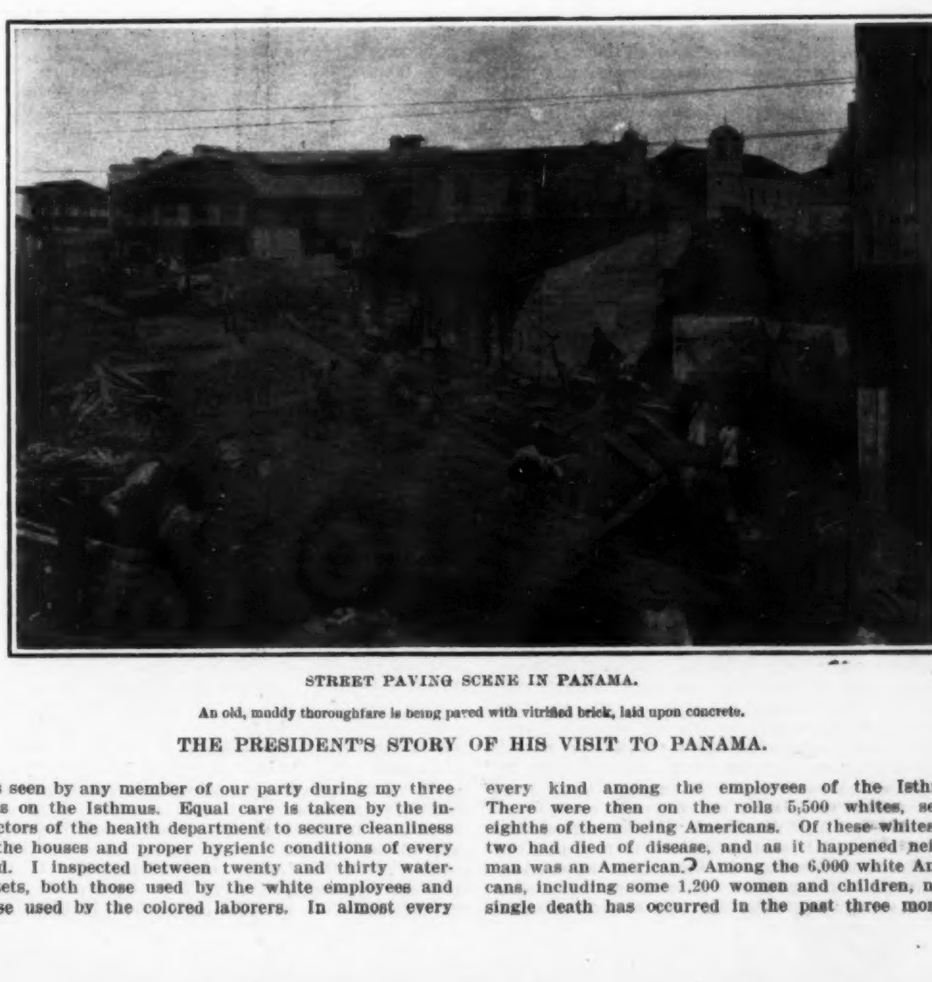
An inspection on the ground at the height of the rainy season served to convince me of the wisdom of Congress in refusing to adopt either a high-level or a sea-level canal. There seems to be a universal agreement among all people competent to judge that the Panama route, the one actually chosen, is much superior to both the Nicaragua and Darien routes.

The wisdom of the canal management has been shown in nothing more clearly than in the way in which the foundations of the work have been laid. To have yielded to the natural impatience of ill-informed outsiders and begun all kinds of experiments in work prior to a thorough sanitation of the Isthmus, and to a fairly satisfactory working out of the problem of getting and keeping a sufficient labor supply, would have been disastrous. The various preliminary measures had to be taken first; and these could not be taken so as to allow us to begin the real work of construction prior to January 1 of the present year. It then became necessary to have the type of the canal decided, and the only delay has been the necessary delay until the 29th day of June, the date when the Congress definitely and wisely settled that we should have an 85-foot level canal. Immediately after that the work began in hard earnest and has been continued with increasing vigor ever since; and it will continue so to progress in the future. When the contracts are let the conditions will be such as to insure a constantly increasing amount of performance.

The first great problem to be solved, upon the solution of which the success of the rest of the work depended, was the problem of sanitation. This was from the outset under the direction of Dr. W. C. Gorgas, who is to be made a full member of the Commission if the law as to the composition of the Commission remains unchanged. It must be remembered that his work was not mere sanitation as the term is understood in our ordinary municipal work. Throughout the Zone and in the two cities of Panama and Colon, in addition to the sanitation work proper, he has had to do all the work that the Marine Hospital Service does as regards the nation, that the health department officers do in the various States and cities, and that Col. Waring did in New York when he cleaned its streets. The results have been astounding. The Isthmus had been a byword for deadly unhealthfulness. Now, after two years of our occupation the conditions as regards sickness and the death rate compare favorably with reasonably healthy localities in the United States. Especial care has been devoted to minimizing the risk due to the presence of those species of mosquitoes which have been found to propagate malarial and yellow fevers. In all the settlements, the little temporary towns or cities composed of the white and black employees, which grow up here and there in the tropic jungle as the needs of the work dictate, the utmost care is exercised to keep the conditions healthy. Everywhere are to be seen the drainage ditches which in removing the water have removed the breeding places of the mosquitoes, while the whole jungle is cut away for a considerable space around the habitations, thus destroying the places in which the mosquitoes take shelter. These drainage ditches and clearings are in evidence in every settlement, and, together with the invariable presence of mosquito screens around the piazzas, and of mosquito doors to the houses, not to speak of the careful fumigation that has gone on in all infected houses, doubtless explain the extraordinary absence of mosquitoes. As a matter of fact, but a single mosquito, and this not of the dangerous species, was seen by any member of our party during my three days on the Isthmus. Equal care is taken by the inspectors of the health department to secure cleanliness in the houses and proper hygienic conditions of every kind. I inspected between twenty and thirty water-closets, both those used by the white employees and those used by the colored laborers. In almost every case I found the conditions perfect. In but one case did I find them really bad. In this case, affecting a settlement of unmarried white employees, I found them very bad indeed, but the buildings were all inherited from the French company and were being used temporarily while other buildings were in the course of construction; and right near the defective water-closet a new and excellent closet with a good sewer pipe was in process of construction and nearly finished. Nevertheless this did not excuse the fact that the bad condition had been allowed to prevail. Temporary accommodations, even if only such as soldiers use when camped in the field, should have been provided. Orders to this effect were issued. I was struck, however, by the fact that in this instance, as in almost every other where a complaint was made which proved to have any justification whatever, it appeared that steps had already been taken to remedy the evil complained of, and that the trouble was mainly due to the extreme difficulty, and often impossibility, of providing in every place for the constant increase in the number of employees. Generally the provision is made in advance, but it is not possible that this should always be the case; when it is not there ensues a period of time during which the conditions are unsatisfactory, until a remedy can be provided; but I never found a case where the remedy was not being provided as speedily as possible.

I inspected the large hospitals at Ancon and Colon, which are excellent examples of what tropical hospitals should be. I also inspected the receiving hospitals in various settlements. I went through a number of the wards in which the colored men are treated, a number of those in which the white men are treated—Americans and Spaniards. Both white men and black men are treated exactly alike, and their treatment is as good as that which could be obtained in our first-class hospitals at home. All the patients that I saw, with one or two exceptions, were laborers or other employees on the canal works and railways, most of them being colored men of the ordinary laborer stamp. Not only are the men carefully cared for whenever they apply for care, but so far as practicable a watch is kept to see that if they need it they are sent to the hospitals, whether they desire to go or not. From no responsible source did any complaint come to me as to the management of the hospital service, although occasionally a very ignorant West India negro when he is first brought into the hospital becomes frightened by the ordinary hospital routine.

Just at present the health showing on the Isthmus is remarkably good—so much better than in most sections of the United States that I do not believe that it can possibly continue at quite its present average. Thus, early in the year a band of several hundred Spaniards were brought to the Isthmus as laborers, and additions to their number have been made from time to time; yet since their arrival in February last but one of those Spaniards thus brought over to work on the canal has died of disease, and he of typhoid fever. Two others were killed, one in a railroad accident, and one by a dynamite explosion. There has been for the last six months a well-nigh steady decline in the death rate for the population of the Zone, this being largely due to the decrease in deaths from pneumonia, which has been the most fatal disease on the Isthmus. In October there were ninety-nine deaths of every kind among the employees of the Isthmus. There were then on the rolls 5,500 whites, seven-eighths of them being Americans. Of these whites but two had died of disease, and as it happened neither man was an American. Among the 6,000 white Americans, including some 1,200 women and children, not a single death has occurred in the past three months,



STREET PAVING SCENE IN PANAMA.

An old, muddy thoroughfare is being paved with vitrified brick, laid upon concrete.

THE PRESIDENT'S STORY OF HIS VISIT TO PANAMA.

whereas in an average city in the United States the number of deaths for a similar number of people in that time would have been about thirty from disease. This very remarkable showing cannot of course permanently obtain, but it certainly goes to prove that if good care is taken the Isthmus is not a particularly unhealthy place. In October, of the 19,000 negroes on the roll eighty-six died from disease; pneumonia being the most destructive disease, and malarial fever coming second. The difficulty of exercising a thorough supervision over the colored laborers is of course greater than is the case among the whites, and they are also less competent to take care of themselves, which accounts for the fact that their death rate is so much higher than that of the whites, in spite of the fact that they have been used to similar climatic conditions. Even among the colored employees it will be seen that the death rate is not high.

In Panama and Colon the death rate has also been greatly reduced, this being directly due to the vigorous work of the special brigade of employees who have been inspecting houses where the Stegomyia mosquito is to be found and destroying its larvæ and breeding places, and doing similar work in exterminating the malarial mosquitoes—in short, in performing all kinds of hygienic labor. A little over a year ago all kinds of mosquitoes, including the two fatal species, were numerous about the Culebra cut. In this cut during last October every room of every house was carefully examined, and only two mosquitoes, neither of them of the two fatal species, were found. Unfaltering energy in inspection and in disinfecting and in the work of draining and of clearing brush are responsible for the change. The surgeon-general reported to me that the hygienic conditions on the Isthmus were about as good as, for instance, those in the Norfolk navy yard.

Corozal, some four miles from La Boca, was formerly one of the most unsanitary places on the Isthmus, probably the most unsanitary. There was a marsh with a pond in the middle. Dr. Gorgas had both the marsh and pond drained and the brush cleared off, so that now, when I went over the ground, it appeared like a smooth meadow intersected by drainage ditches. The breeding places and sheltering spots of the dangerous mosquitoes had been completely destroyed. The result is that Corozal for the last six months (like La Boca, which formerly also had a very unsanitary record), shows one of the best sick rates in the Zone, having less than 1 per cent a week admitted to the hospital. At Corozal there is a big hotel filled with employees of the Isthmian Canal Commission, some of them with their wives and families. Yet this healthy and attractive spot was stigmatized as a "hog wallow" by one of the least scrupulous and most foolish of the professional scandalmongers who from time to time have written about the Commission's work.

The sanitation work in the cities of Panama and Colon has been just as important as in the Zone itself, and in many respects much more difficult, because it was necessary to deal with the already existing population, which naturally had scant sympathy with revolutionary changes, the value of which they were for a long time not able to perceive. In Colon, the population consists largely of colored laborers who, having come over from the West Indies to work on the canal, abandon the work and either take to the brush or lie idle in Colon itself, thus peopling Colon with the least desirable among the imported laborers, for the good and steady men of course continue at the work. Yet astonishing progress has been made in both cities. In Panama 90 per cent of the streets that are to be paved at all are already paved with an excellent brick pavement laid in heavy concrete, a few of the streets being still in process of paving. The sewer and water services in the city are of the most modern hygienic type, some of the service having just been completed.

In Colon the conditions are peculiar, and it is as regards Colon that most of the very bitter complaint has been made. Colon is built on a low coral island, covered at more or less shallow depths with vegetable accumulations or mold, which affords sustenance and strength to many varieties of low-lying tropical plants. One-half of the surface of the island is covered with water at high tide, the average height of the land being 1½ feet above low tide. The slight undulations furnish shallow, natural reservoirs or fresh-water breeding places for every variety of mosquito, and the ground tends to be lowest in the middle. When the town was originally built no attempt was made to fill the low ground, either in the streets or on the building sites, so that the entire surface was practically a quagmire; when the quagmire became impassable certain of the streets were crudely improved by filling especially bad mud holes with soft rock or other material. In September, 1905, a systematic effort was begun to formulate a general plan for the proper sanitation of the city; in February last temporary relief measures were taken, while in July the prosecution of the work was begun in good earnest. The results are already visible in the sewering, draining, guttering, and paving of the streets. Some four months will be required before the work of sewerage and street improvement will be completed, but the progress already made is very marked. Ditches have been dug through the town, connecting the salt water on both sides, and into these the ponds, which have served as breeding places for the mosquitoes, are drained. These ditches have answered their purpose, for they are probably the chief cause of the astonishing diminution in the number of mosquitoes. More ditches of the kind are being constructed.

It was not practicable, with the force at the Commission's disposal, and in view of the need that the force should be used in the larger town of Panama, to begin this work before early last winter. Water mains were then laid in the town and water was furnished to the people early in March from a temporary reservoir. This reservoir proved to be of insufficient capacity before the end of the dry season and the shortage was made up by hauling water over the Panama Railroad, so that there was at all times an ample supply of the very best water. Since that time the new reservoir back of Mount Hope has been practically completed. I visited this reservoir. It is a lake over a mile long and half a mile broad. It now carries some 500,000,000 gallons of first-class water. Nothing but a cataclysm will hereafter render it necessary in the dry season to haul water for the use of Colon and Cristobal.

One of the most amusing (as well as dishonest) attacks made upon the Commission was in connection with this reservoir. The writer in question usually confined himself to vague, general mendacity; but in this case he specifically stated that there was no water in the vicinity fit for a reservoir (I drank it, and it was excellent), and that this particular reservoir would never hold water anyway. With typical American humor, the engineering corps still at work at the reservoir have christened a large boat which is now used on the reservoir by the name of the individual who thus denied the possibility of the reservoir's existence.

I rode through the streets of Colon, seeing them at the height of the rainy season, after two days of almost unexampled downpour, when they were at their very worst. Taken as a whole they were undoubtedly very bad; as bad as Pennsylvania avenue in Washington before Grant's administration. Front Street is already in thoroughly satisfactory shape, however. Some of the side streets are also in good condition. In others the change in the streets is rapidly going on. Through three-fourths of the town it is now possible to walk, even during the period of tremendous rain, in low shoes without wetting one's feet, owing to the rapidity with which the surface water is carried away in the ditches. In the remaining one-fourth of the streets the mud is very deep—about as deep as in the ordinary street of a low-lying prairie river town of the same size in the United States during early spring. All men to whom I spoke were a unit in saying that the conditions of the Colon streets were 100 per cent better than a year ago. The most superficial examination of the towns shows the progress that has been made and is being made in macadamizing the streets. Complaint was made to me by an entirely reputable man as to the character of some of the material used for repairing certain streets. On investigation the complaint proved well founded, but it also appeared that the use of the material in question had been abandoned, the Commission after having tried it in one or two streets finding it not appropriate.

The result of the investigation of this honest complaint was typical of what occurred when I investigated most of the other honest complaints made to me. That is, where the complaints were not made wantonly or maliciously, they almost always proved due to failure to appreciate the fact that time was necessary in the creation and completion of this Titanic work in a tropic wilderness. It is impossible to avoid some mistakes in building a giant canal through jungle-covered mountains and swamps, while at the same time sanitating tropic cities, and providing for the feeding and general care of from twenty to thirty thousand workers. The complaints brought to me, either of insufficient provision in caring for some of the laborers, or of failure to finish the pavements of Colon, or of failure to supply water, or of failure to build wooden sidewalks for the use of the laborers in the rainy season, on investigation proved, almost without exception, to be due merely to the utter inability of the Commission to do everything at once.

For instance, it was imperative that Panama, which had the highest death rate, and where the chance of a yellow fever epidemic was strongest, should be cared for first; yet most of the complaints as to the delay in taking care of Colon were due to the inability or unwillingness to appreciate this simple fact. Again, as the thousands of laborers are brought over and housed, it is not always possible at the outset to supply wooden walks and bath houses, because other more vital necessities have to be met; and in consequence, while most of the settlements have good bath houses, and, to a large extent at least, wooden walks, there are plenty of settlements where wooden walks have not yet been laid down, and I visited one where the bath houses have not been provided. But in this very settlement the frames of the bath houses are already up, and in every case the utmost effort is being made to provide the wooden walks. Of course, in some of the newest camps tents are used pending the building of houses. Where possible, I think detached houses would be preferable to the semi-detached houses now in general use.

Care and forethought have been exercised by the Commission, and nothing has reflected more credit upon them than their refusal either to go ahead too fast or to be deterred by the fear of criticism from not going ahead fast enough. It is curious to note the fact that many of the most severe critics of the Commission criticise them for precisely opposite reasons, some complaining bitterly that the work is not in a more advanced condition, while the others complain that it has been rushed with such haste that there has been insufficient preparation for the hygiene and comfort of the employees. As a matter of fact neither criticism is just. It would have been impossible to go quicker than the Commission has gone, for such quickness would have meant insufficient preparation. On the other hand, to refuse to do anything until every possible future contingency had been met would have caused wholly unwarranted delay. The right course to follow was exactly the course which has been followed. Every reasonable preparation was made in advance, the hygienic conditions in especial being made as nearly perfect as possible; while on the other hand there has been no timid refusal to push forward the work because of inability to anticipate every possible emergency, for, of course, many defects can only be shown by the working of the system in actual practice.

In addition to attending to the health of the employees, it is of course necessary to provide for policing the Zone. This is done by a police force which at present numbers over 200 men, under Capt. Shanton. About one-fifth of the men are white and the others black. In different places I questioned some twenty or thirty of these men, taking them at random. They were a fine set, physically and in discipline. With one exception all of the white men I questioned had served in the American army, usually in the Philippines, and belonged to the best type of American soldier. Without exception the black policemen whom I questioned had served either in the British army or in the Jamaica or Barbados police. They were evidently contented, and were doing their work well. Where possible the policemen are used to control people of their own color, but in any emergency no hesitation is felt in using them indiscriminately.

Inasmuch as so many both of the white and colored employees have brought their families with them, schools have been established, the school service being under Mr. O'Connor. For the white pupils white American teachers are employed; for the colored pupils there are also some white American teachers, one Spanish teacher, and one colored American teacher, most of them being colored teachers from Jamaica, Barbadoes, and St. Lucia. The schoolrooms were good, and it was a pleasant thing to see the pride that the teachers were taking in their work and their pupils.

There seemed to me to be too many saloons in the Zone; but the new high-license law which goes into effect on January 1 next will probably close four-fifths of them. Resolute and successful efforts are being made to minimize and control the sale of liquor.

The cars on the passenger trains on the Isthmus are divided into first and second class, the difference being marked in the price of tickets. As a rule second-class passengers are colored and first-class passengers white; but in every train which I saw there were a number of white second-class passengers, and on two of them there were colored first-class passengers.

(To be continued.)

BYGONE PEVENSEY.

THERE are two Pevenseys known to history—the village that is of the British Empire, and the city that was of the Roman Empire. The former lives its life of rural contentment, yet breathes the musty breath of the past; the other, save its walls, is buried in Cimmerian darkness, only pierced by the researches of our archæologists and antiquarians.

The inclosure within those grim, ivy-clad Roman walls first echoed with the spade of the excavator four-and-fifty years ago, when, fostered by the Sussex Archæological Society, investigations were carried on by Messrs. M. A. Lower and C. Roach Smith, F.S.A., but no striking discoveries were made. Existing information with regard to the early history of the ancient city is very meager, and, says the Sussex Daily News, a committee to carry out a scheme of excavations which would throw considerable light on it has been formed. Mr. L. F. Salzmann, who contributed to the Victorian History the introduction and translation of the Domesday text in regard to Sussex and the political history of Sussex, and who wrote the "History of Hailsham," is superintending the excavations, and Mr. J. E. Ray is assisting. Both are members of the Sussex Archæological Society.

Seven trial shafts were sunk, in some cases to a depth of 9 feet, and the ancient pathway from the north postern gate was disclosed at a distance from the walls. From the result of these trials the committee laid their preliminary plans, and the intention is to follow the path, commencing at the postern, until it converges with the ancient path from the main gate on the west to the one on the Pevensey side. Here it is anticipated foundations of buildings will be unearthed. No general plan, of course, can be drawn up, as future discoveries may render it necessary to alter procedure. It is also intended to secure a foundation plan of the great entrance or Decuman gate on the west, and a ground plan of the Mediæval castle in the southeast corner of the Roman area, and to explore the mound in the keep. Mr. Sands will have charge of the work dealing with the castle.

The fact that the ten acres inclosed within the Roman walls at Pevensey is the site of the Romano-British city of Anderida is, after years of controversy, now generally admitted. All the Roman stations on the Sussex littoral were identified by both modern and ancient names except one. There were at one time seven candidates for the honor of being the long-lost city of Anderida, but Pevensey presented the best credentials and secured her birthright. Possibly some discovery will be made in these excavations which will confirm it. It requires but a slight stretch of the imagination to conceive the waves of Pevensey Bay, then a deeper indent, lapping the foot of the eminence on which the Roman strategists built their 12-foot-thick walls about A. D. 300, and that vast alluvial

deposit, Pevensey Marsh, a swamp. The fact that the main defense, the great gate, is on the west side and the towers closer together there supports the contention that the peninsula was accessible from that land side only. The Romans neglected the usual rectangular camp and adapted the walls to the configuration of the ground, thereby inclosing a roughly oval space. Excavations at most other Roman stations, therefore, can serve as no criterion for a plan here. Trouble across the Channel called the Romans away, and they left the Britons, who had received their civilizing influence, at Andredceaster. They were "citizens," we are told, so the place must have been of importance. Then the South Saxons came along about the year 490 and "besieged Andredceaster, a strongly-fortified city." When they left there were no Britons there, and "only the desolate site of a very noble city is pointed out to those who pass." Deathly silence, historically, reigns over the once "noble city" for over five hundred years, although there are traces of slight Saxon "herring-bone" repairs to the walls.

Then the great event occurred which made the name of Pevensey ring down through the pages of history, as it will as long as English history lasts—the landing there of William the Conqueror. There are evidences of the walls of the "desolate city" being very convenient for defense, as they exhibit now traces of Norman masonry, and of a fortress being erected within. This was destroyed and the Norman castle, the ruins of which stand to-day, was evidently erected on the site. Pevensey then entered on lively times and things looked up locally. The castle was besieged several times. Stephen "found it too strong to be taken by storm," King John ordered it to be demolished, which was probably not done; deserting earls from the battle of Lewes took shelter there, and at last it fell into the hands of the Crown, more or less ruined. As a prison it held James I. of Scotland, Edward Duke of York, and Joan of Navarre, queen of Henry IV. In 1587 the threatened Spanish invasion caused a survey of the coast of Sussex to be made with a view of defense. Then it was suggested that Pevensey Castle should be "re-edified or utterly razed," but neither appears to have been done.

The erection of the castle resulted in the original "floor" of the area being covered with a bed of stiff clay, and the seekers after Roman remains have in that an obstacle which makes the work of excavation difficult and more expensive than it would otherwise have been. The walls on the outside are between 24 and 30 feet high, yet so much clay has been dumped inside that it is but a few feet from the wall tops in some places. The digging of the moat accounts for some of the accumulation, but where the greater part of it came from is a mystery at present.

Numbers of Roman coins have been found among the ruins, and possibly more may now be dug up. In this connection it is interesting to note an attempted fraud about 1850. A man buried considerably over 800 sham coins in the ruins, and then reported that he had hit upon a "find." He made the fatal mistake, however, of burying them in a tower built in the reign of Edward II., and the numismatic gentlemen became suspicious and found him out. Many a house in the neighborhood is indebted to the old fortress for its walls, as it served as a "quarry" for years. Stout brick buttresses were then found necessary to repair and prevent further damage. The kind permission of the Duke of Devonshire, the owner, and of Mr. William Elphick, the tenant, was extended to the excavators to carry on the work.

HERCULANEUM MANUSCRIPTS.

SOME of the manuscripts found at Herculaneum are of one palm high, others two or three, and the rolls which they carry are nearly four fingers thick, though some are only half a palm. They are, generally speaking, burnt to a cinder, and, according to the exterior, might be taken for petrified wood. As to square books in our fashion not a single one occurs. These manuscripts were written on Egyptian paper, and by the examination of many which are less dry and wrinkled, and which notwithstanding were rolled as close as they now appear, they have not been compressed by the heat into a smaller bulk than that which they now occupy. A roll of this sort is formed of many pieces, thin and as large as the hand, which, being fastened at the end of each other, form at their junction a fold of a finger's breadth, and are so well united that nothing is capable of severing them. The ancients had artisans called glutinatores, whose profession it was to paste these leaves, and they must not be confounded with common workmen, for the Athenians elevated a statue to one Philtatius, who had taught them the art of pasting the manuscripts, or, what appears more probable, had invented a kind of paste proper for books. Some of these rolls, composed of many pieces pasted together, were simply curled up; others had a tube of wood or bone (the umbilicus) round which they were entwined (like our pendulous maps and charts); others have been presumed to have had two, and both appear in a painting of Herculaneum, but no second tube occurs. They were opened and read as we should do pedigrees. The manuscripts are written upon one side only, and the written side is placed in the interior of the roll. Winckelmann concludes that manuscripts written on both sides were executed upon double or doubled paper. All these works are written in columns about four fingers broad, i. e., occupying as much space as a Greek verse of six feet. One column contains in some MSS. forty lines and in others forty-four. Between the columns the space of a finger is left blank. The columns have been framed in red lines, as usual with many books in the first copies. There is no appearance, as upon parchment, of ruled lines to direct the writing; but as the paper was exceedingly fine, and appears to have been transparent, they used a leaf of ruled paper beneath. Pliny speaks of manuscripts written upon double paper, i. e., composed of two leaves pasted upon each other, so that one of these leaves was placed upon the length and the other upon the breadth, and the grain of the paper was crossed.

ENGINEERING NOTES.

That the contest for supremacy between gun and armor has not yet terminated has been very strikingly demonstrated in the course of some recent experiments that have been carried out by the British Admiralty. In this instance a new type of projectile of the armor-piercing type was used, the distinctive feature of which is that instead of the head terminating in a sharp point there is a spherical hollow. The shell was of the 6-inch type, and when discharged against an armor plate of the same character and thickness as that utilized for the protective belting of the "Dreadnought" on the waterline, it completely penetrated it.

In the course of a recent inquiry into the cause of a fatal colliery explosion in England an interesting experiment that was conducted for demonstrating the possibility of the gases being fired by sparks produced by the fall of the roof, was explained. At one of the Welsh collieries the gas which was found to be present in a gallery 240 feet below was pumped through pipes to the surface. This gas was then discharged into a large airtight box. Within this chest there was placed a large stone brought from the pit, which was securely fastened to one side of the interior. Upon a revolving pulley within the box was suspended another similar stone, and by means of the pulley it was possible to strike one stone sharply against the other and thereby produce sparks. When the chest was fully charged with gas, the two stones were brought into sharp contact. At the second blow a loud explosion resulted, which blew the heavy cover off the box and sent a sheet of flame several feet into the air. The experiment was repeated, only in this instance the gas from the mine was mixed with coal dust from the screens. On this occasion the explosion was more violent when the stones struck one another, thereby conclusively proving that a falling roof is quite capable of producing a serious catastrophe by the gas becoming ignited with the sparks produced in the fall.

Things are always getting done in the sense of wearing out, and in the design, as well as in the construction, of civil engineering works we are prone to forget that we are, so to speak, constantly overhung by the sword of Damocles, in the form of ultimate and stern necessity for expenditure in repair and renewal. Structures and materials of all kinds are continually wasting and wearing out, and the question attaching to their maintenance and the necessity of their renewal are so important and so difficult as to merit very special consideration. The problem of the preservation of stone and steel, for example, remains unsolved, and in design and construction their lasting qualities are a continual source of anxiety to the civil engineer. Both of these materials are continually wearing out. A great fortune awaits the young civil engineer who produces a proper and lasting preservative, or rather, a sure preventive against decay.

Two schemes of a gigantic nature have been projected for improving the facilities of the port of London, and which when completed will be greatly appreciated by the various shipping companies whose freight is destined for transshipment or discharge in the Thames. The first of these comprises the provision of extensive accommodation at Greenhithe, which is situated near the estuary of the Thames. The principle of the scheme is similar to that which has been provided at the port of Antwerp, and which has proved so eminently successful. A long wharf some 3,600 feet in length is to be erected in the water and running parallel with the shore at a point where a depth of 30 feet of water will be available at the lowest tide. Incoming vessels will moor upon the outer edge of this wharf, and their cargoes will be transferred by transportation plants either to the deck of the quay or to barges which will be moored upon the inside of the wharf, and by the latter conveyed up the river to London itself. By this means vessels will be saved the necessity of traveling up the Thames to the London docks, the avoidance of which, owing to the congested traffic on the river and the narrow width of the waterway, will result in an appreciable economy in time and moreover, what is equally important, great expense. A great portion of the freights landed at the London docks is destined for transshipment to Continental ports or to other parts of the kingdom, so that the provision of this ocean wharf will overcome the objections that at present often confront the smaller types of freight boats, and obviate the delays often experienced in reaching the wharves by waiting for the tides. The second project comprises the construction of a tunnel beneath the river exclusively for railroad traffic and connecting the opposite banks, thereby affording a direct communicating link between the trunk railroads north and south of the Thames respectively without passing through the city of London itself, as is now essential. The total length of the tunnel and its approaches upon either side will be 4½ miles, of which aggregate 1½ miles will be tunneling beneath the river. At this point the bed of the waterway is solid chalk, through which boring operations can be quickly and easily carried out. The gradients in no instance will be more than 1 in 100, so that the railroad will be easy to work; and as electric haulage is to be adopted, it will enable an unlimited quantity of traffic to pass to and fro. On the south side the railroad will be connected to the extensive ocean wharf which is to be erected at Greenhithe, so that the freight landed at this point for various parts of the United Kingdom can be expeditiously picked up and distributed, thereby avoiding congestion on the wharf. The total cost of the enterprise, including construction of tunnel and approaches, the installation of the necessary electrical equipment, and sidetracks, will range from $3,500,000 to $4,000,000.

SCIENCE NOTES.

For the purposes of registering the intensity of sound the police department of London have commissioned a well-known scientist to evolve a device, whereby it will be possible to obtain a definite and inscribed record of any sound volume, from the buzz of a fly to the blast of a syren, and preliminary experiments with this apparatus have been carried out by Lord Rayleigh which have been attended with complete success. This "phonometer," as it is called, has been rendered necessary owing to the public outcry that has been raised by the noise emitted by motor omnibuses and other vehicles engaged in traffic in the metropolis. These vehicles being registered by the department of police, the officials have been considerably puzzled in determining what is undue noise, owing to the absence of any standard in the measurement of sound. Consequently, many of the licenses have been refused arbitrarily, and such withdrawal has imposed undue hardship upon the owners of the vehicles. With this sound-measuring instrument, however, a standard will be obtainable, and it will then be easy to determine when the noise emitted by any vehicle exceeds the limits permitted, without any dependence upon the varying human element.

A discovery of curious interest has been made by Mr. Hans Vischer, the British resident at Kuka on Lake Chad, in the course of a hazardous exploration he is making in the Sahara desert. In the country around the Gharian mountains a colony of cave dwellers was found. The strange inhabitants of these subterranean residences excavate a huge, deep hole in the ground, which forms a kind of quadrange or courtyard, reached by means of narrow entrances about thirty feet in length by three feet broad. All the rooms and other apartments of the occupiers open upon this courtyard, being excavated out of the solid earth upon all sides, the internal lighting of the apartments being gained from the aperture opening upon the quadrangle. The rooms themselves are very dark. To protect the dwellings underneath, there is a wall which is carried right round the courtyard. A remarkable feature of this strange community is the absolute cleanliness that prevails everywhere. In strange contrast to these subterranean villages are the remains to be observed on all sides of Roman dwellings and evidences of their occupation scattered incongruously among the primitive habitations of the natives.

The services which chemistry can render to the elucidation of the problems of rubber production and utilization are very numerous. Methods of treatment depending on a knowledge of the other constituents of the latex have led to the production of rubber in a purer condition. Much still remains to be elucidated by chemical means as to the nature of the remarkable coagulation of the latex. As is well known, the latex is a watery fluid resembling milk in appearance which contains the rubber, or, more probably, the immediate precursor of rubber, together with proteids and other minor constituents. The constituent furnishing rubber is in suspension, and rises like cream when the latex is at rest. On the addition of an acid, or sometimes of alkali, or even on mere exposure, coagulation takes place and the rubber separates as a solid, the other constituents for the most part remaining dissolved in the aqueous liquid or "serum." The first view taken of the nature of the coagulation process was that, like the coagulation of milk by acids, it is dependent upon a process of proteid coagulation, the separated proteids carrying down the rubber during precipitation. This explanation cannot, however, be considered complete by the chemist, and there are peculiarities connected with the coagulation of the latex which are opposed to the view that it is wholly explained by the coagulation of the associated proteids. The experimental investigation of the question on the chemical side is beset with many difficulties which are increased if access cannot be had to fresh latex. A number of experiments were made at the Imperial Institute with latex forwarded from India. The difficulties contended with in preventing coagulation during transit were great, but in the case of the latex derived from certain plants these were to some extent surmounted, and the results obtained, especially with reference to the behavior of certain solvents toward the latex, led to the conclusion that "coagulation" can take place after removal of the proteids, and that in all probability it is the result of the polymerization of a liquid which is held in suspension in the latex and on polymerization changes into the solid colloid which we know as caoutchouc. Weber, by experiments conducted in South America with fresh latex, arrived at a similar conclusion, which later workers have confirmed. Although the nature of the process is not yet completely elucidated, there is little room for doubt that the coagulation is due to the polymerization of a liquid and possibly of a liquid hydrocarbon contained in the latex. For the chemist the important question remains as to the nature of this liquid.

PERTURBATIONS IN LOCOMOTION.

By G. Bolin.

Animals that are capable of locomotion usually possess bilateral symmetry, while stationary animals have radiate symmetry. The former are generally of elongated form and composed of right and left halves, more or less similar, separated by a median plane. Progression is usually in a straight line lying in this plane, whether we consider the creeping of worms and mollusks, the walking of crustaceans and mammals, the swimming of larvæ and fishes, or the flight of insects and birds. But there are exceptions to this rule.

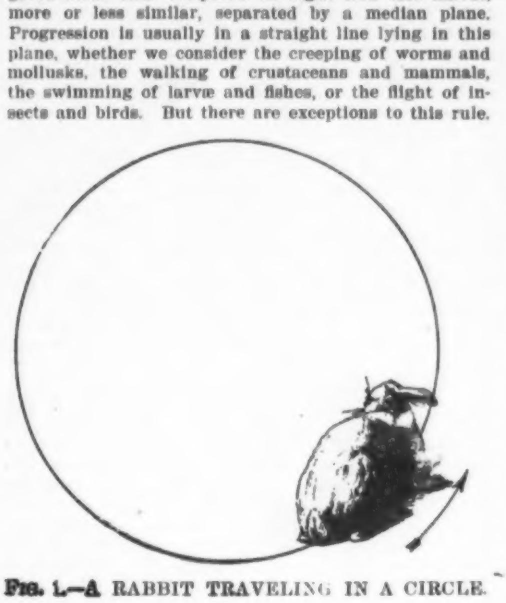


Fig. 1.—A RABBIT TRAVELING IN A CIRCLE.

Crabs flee in a direction perpendicular to their plane of symmetry and mosquitoes describe many circles in the air in their whirling flight.

Rotary motions occur normally in certain animals and in others they can be induced by various methods.

Rotary Movements of Vertebrates.—These movements were thoroughly studied by Beaunis and are described in his Nouveaux Elements de Physiologie. They present themselves under three different forms:

1. Traveling in a Circle.—In this case (Fig. 1) the animal describes a circle of greater or smaller radius with which the axis of the body, bent into a circular arc, always coincides. The revolution is sometimes in the opposite direction. Occasionally the animal describes, instead of a circle, a series of curves of different radii of curvature, forming a sort of spiral.

2. Rotating Like the Spoke of a Wheel (Fig. 2).—In this case the axis of the animal's body remains straight and forms part of a radius instead of the circumference of the circle. The animal may turn about its hind legs as an axis, with its head at the circumference. This method of rotation, which is very rare, has been observed by Schiff, Brown-Séquard, and Beaunis, that is to say, by physiologists the results of whose experiments cannot be doubted. Bechterew has observed the reverse movement, with the head at the center of the circle.

3. Rotation About the Axis of the Body, or Rolling.—In this movement the animal turns about the longitudinal axis of the body. The rotation is started by a fall of the animal upon one side and the direction of rotation is determined by the side on which it falls. A child voluntarily executes this movement when it allows itself to roll down a grassy slope. The rolling may be accompanied by a movement of translation, and thus become a screw motion.

All these rotary movements are very rapid and they usually have a peculiar character. It seems, says

Fig. 2.—A RABBIT ROTATING ABOUT ITS HIND FEET.

Beaunis, as if the animals were impelled to perform them by an internal force to which they can offer no resistance. Hence the name *Zwangbewegungen*, or irresistible movements, which has been applied to them.

Origin and Interpretation of These Movements.—These movements are obtained by making certain lesions of the nervous centers (Fig. 3) at the levels of the posterior, middle, and front brain (cerebellum, corpora quadrigemina, and cerebral hemispheres). It is sufficient, for example, to cut one of the peduncles which connect the cerebellum, at the right and the left, with the subjacent parts, to provoke rolling about the longitudinal axis. The movement of progression in a circle is observed chiefly after lesion of the peduncles which attach the cerebral hemispheres to the other parts of the encephalon, but occasionally it follows even small lesions of the cortex, or superficial portion of the hemispheres.

Attempts have been made to explain these rotations by a complete or partial paralysis of the muscles of one side of the body, as well as by a contraction of the same muscles, but in most cases there is neither contraction nor paralysis. According to Gratiolet the rotation is due to convulsions of the ocular muscles and to the vertigo which accompanies the deviation of the eyes. Such convulsions are often associated with the rotations and the deviation of the eyes is ordinarily in the same direction as the movement of rotation, but there is no necessary connection between the two phenomena, as the rotations may persist after the removal of the eyes.

Many movements of rotation appear to have their origin in the motor centers. In view of this, Magendie, one of the fathers of the physiology of the nervous system, admitted the existence, in the various cerebral areas, of organs having antagonistic effects on movements—a center of progression and one of retrogression, a center of motion toward the right and one of motion toward the left. Both in rest and in locomotion equilibrium would be maintained by the reciprocal neutralization of the actions of antagonistic nerve centers, but if one of the opposing centers were destroyed or immoderately stimulated the equilibrium would be disturbed and the predominating action of the remaining or over-excited center would cause the body to deviate to one side or the other. This is the explanation given by Vulpian, by Luys, who compares the phenomenon of rotation to the physical phenomenon of the hydraulic tourniquet, and by Onimus, who makes the movement of progression in a circle depend on an exaggerated functional activity of one lateral half of the system of locomotor nerve centers. Beaunis himself concludes that no complete theory of movements of rotation is possible in the present state of science.

Furthermore, movements of rotation may have a

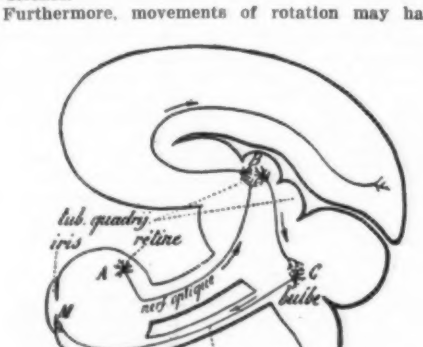


Fig. 3.—DIAGRAM OF BRAIN.

C. Cerebellum. B. Corpora quadrigemina.

peripheral, instead of a central origin. They can be induced by injuries to certain parts of the ear as well as by cerebral lesions. The internal ear (Fig. 4), which is inclosed in one of the bones of the skull, is composed of two chambers, of which one forms the termination of a spirally coiled tube called the cochlea (L), while the other communicates with three tubes called the semicircular canals (*csc*), filled with liquid. The motions of this liquid affect nerve terminations situated in a bulbous expansion near the end of each canal in which the phenomena under discussion appear to originate.

Flourens was the first to observe the very curious phenomena caused by cutting the semicircular canals of pigeons. Section of the horizontal canal provoked movements of the head from side to side; section of the vertical canal is followed by up-and-down movements. In other words, the head moves in the plane of the severed canal. Destruction of the canals produces vertigo, followed by rotary movements, the pigeon being unable to maintain its equilibrium. These phenomena have since been observed many times, but their interpretation still presents many difficulties.

Circular Progression of Insects.—In insects, locomotion in a circle can be induced very easily by unilateral lesion of the nervous ganglia. The facility with which this symptom is produced makes it, according to the psychologist Binet, one of the most important characteristics of the nervous physiology of these animals. Any serious injury of a nerve ganglion usually results in compelling the wounded animal to walk in a circle.

Treviranus appears to have been the first to make this experiment. He removed the left half of the ganglion beneath the esophagus from an *Oryza* and observed that the insect moved rapidly in circles, always turning to the right. The experiment has been repeated by Yersin, Faivre, and R. Dubois.

These investigators observed circular motion caused by unilateral lesion of the nervous centers, but, according to Binet, the same phenomena may be produced by a very different method. It is sufficient for this purpose to affix a small piece of wax to the outer edge of a wing cover of the insect—a cockroach, for example. The weight must be in proportion to the size of the insect; not great enough to turn it over on its side or back, but yet sufficient to change the direction of progression. The insect moves in a circle (Fig. 5) and Binet has proved that it does so because it takes longer strides with the legs of one side than with those of the other. In Binet's opinion, therefore, the primary cause of the circular movement consists of an unequal excitation of the two sides of the body, and the phenomenon is independent of the will of the insect.

Although the insect sometimes struggles, to a certain extent, against the tendency to move in a circle or a spiral (Fig. 6) it always yields at last. For some reason the deviation is inevitable. A cricket of which the right cerebral peduncle has been severed does not remain long beside the piece of bread which it appears to be eating with avidity, but gradually moves off to the left until the food is out of its reach. The insect

Fig. 4.—INNER EAR.

L. Cochlea. csc. Semicircular canals.

seems to be unable to approach the food voluntarily. Again, when an insect which is thus moving in a circle is touched it increases its speed to escape the menacing finger, but it is nevertheless obliged to describe a circular path which may bring it back exactly to its starting point.

Locomotion in Circles Caused by Unequal Illumination of the Two Eyes.—We have seen that movement in a circle may result, not only from alteration of the nervous centers, but also from unsymmetrical alteration or stimulation of the organs of sense, such as the integuments and the semicircular canals. In the case of insects, the amputation of an antenna and the blinding of an eye are frequent causes of this circular motion.

Many experiments have been made with insects and crustaceans with one eye blinded. Cicadas, flies, dragon flies, and bees always turn to the side opposite to the blinded eye, but cockroaches, moths, and other animals which habitually shun the light turn in one or the other direction according to the time of day and the intensity of illumination. Psychological explanations have been offered for these facts. The fly sees an opaque obstacle on the side of the blinded eye and turns away to avoid it. Insects which shun the light of day have their power of attention increased at dusk and can then direct their flight toward objects at which they look. But we must discern in these facts phenomena of biological character. The light received by each eye appears to exert an influence, stimulating in some cases, inhibitory in others, upon those muscles of the corresponding side of the body.

It is only necessary to destroy one eye of an annelid worm, like *Nereis* (Fig. 7) to effect a contorsion which suggests partial paralysis of one side of the body.

These phenomena have a curious result. If a snail is placed between a white wall and a black one (Fig. 8) the resultant inequality of illumination of the two eyes causes the mollusk to crawl along a circular arc which curves toward the black wall. This experiment explains, according to G. Bohn, the negative phototropism of many animals, or the apparent attraction exerted upon them by black walls.

Anatole France on Circular Locomotion.—Anatole France* seems to have had an inkling of the phenomena just described, which have been studied only during the last few years. In "The Well of Ste. Claire" he has reduced to writing a number of old Italian tales,

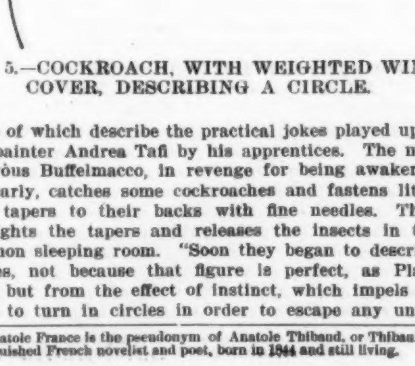


Fig. 5.—COCKROACH, WITH WEIGHTED WING COVER, DESCRIBING A CIRCLE.

some of which describe the practical jokes played upon the painter Andrea Tafi by his apprentices. The mischievous Buffelmacco, in revenge for being awakened too early, catches some cockroaches and fastens little wax tapers to their backs with fine needles. Then he lights the tapers and releases the insects in the common sleeping room. "Soon they began to describe circles, not because that figure is perfect, as Plato says, but from the effect of instinct, which impels insects to turn in circles in order to escape any unac-

* Anatole France is the pseudonym of Anatole Thibaud, or Thibault, a distinguished French novelist and poet, born in 1844 and still living.

customed danger. Buffelmacco looked on from his bed, well pleased with his trick. And truly nothing could have been more marvelous than these lights imitating, on a small scale, the harmony of the spheres as it is represented by Aristotle and his commentators. The cockroaches were not seen, but only the lights which they carried, when these lights were tracing in the darkness more cycles and epicycles than Ptolemy and the Arabians had ever observed in their study of the planetary motions. . . . Tafi burst open the door and fled in terror from the presence (as he thought) of the devil and all his imps."—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La Science au XXme Siècle.

LIGHT AND THE VISUAL SENSE.*

A STUDY IN BIOLOGICAL PHYSICS.

By HENRY A. FOTHERBY, D.Ph. (Camb.), L.R.C.P. (Lond.), etc.

"THE method by which a ray of light is able to stimulate the endings of the optic nerve in the retina in such a manner that the visual sensation is perceived by the cerebrum is not yet understood. It is supposed that the change effected by the agency of the light which falls upon the retina is, in fact, a chemical alteration in the protoplasm, and that this change stimulates the optic nerve endings."—(Halliburton.)

We know that the energy of light as well as heat and electricity are capable of producing chemical action. For instance, if a mixture of chlorine and hydrogen gases, which will keep indefinitely in the dark, is exposed to sunlight they will combine with explosive violence. The principle on which photography depends is the influence of light in producing chemical change in silver chloride, which becomes blackened owing to the reduction of silver. It is from the radiant energy of sunlight that chlorophyl, the green coloring matter of plants, derives chemical energy whereby plants are enabled to build up their tissues from the elements of carbon dioxide and water.

It has been observed that movements take place in the pigment granules of the retinal cells under the influence of light. The retinal cones also shorten in its presence and elongate in its absence. In the retinal rods of certain animals, notably frogs, there is a certain pigment called visual purple, which, though present in the dark, disappears in the presence of light, and reappears again directly the light is withdrawn. The visual purple is also found to undergo distinct changes of color when exposed to other lights than white light.

It was on observations such as these that Hering based his theory of color vision, consisting of six primary color sensations, in opposition to the Young-Helmholtz theory of three only. The former suggests that these consist of three pairs of antagonistic or complemental color sensations, black and white, red and green, yellow and blue, and that the stimulus producing each severally is caused by changes either of disintegration or assimilation taking place in certain three substances of the nature of visual purple, which it is assumed exists in the retina. Thus, in the case of the red-green substance, if assimilation is in excess of disintegration the sensation is red, if the reverse it is green, but when equal no sensation occurs. The Young-Helmholtz theory, on the other hand, teaches that there are only three primary elementary color sensations—red, green, violet—and that the end-organs of the optic nerve in the retina, the rods and cones, consist of three varieties, each one specialized to respond to one of these three color sensations, and

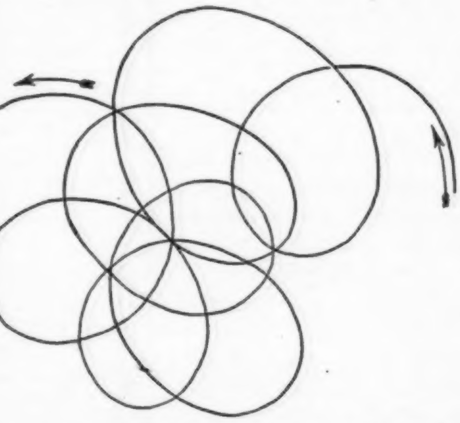


FIG. 6.—PATH FOLLOWED BY A WOUNDED INSECT. (AFTER BINET.)

that all the different shades of color are due to the different degrees in which they are severally excited, the sensation of white being produced only when they are equally stimulated. This latter is the more generally accepted theory of color vision. How these three colors, red, green, and violet, were selected and found to be the only fundamental color sensations would take up too much space to describe here. It must suffice to say that it was due to a series of experiments by which the retina was exhausted for various colors, with the result that the fatigue manifested itself in these three colors, and it was found also that these three color sensations could not be produced by any combination of other color sensations.

The eye is not only a complicated optical instrument, but it is at the same time a vital organ of extreme delicacy functioned for the purpose of receiving sensory impressions of radiant energy, the velocity of whose radiations lies between certain definite limits, and transmitting them to the optic nerve centers in such a way that they can be translated into sensations of light and color. It is owing to this fact that these rays have received the name of luminiferous ether. When the ether vibrations have acquired a velocity of 450 millions of millions a second they affect the retina and become appreciated as the sense of red; as the vibrations increase in velocity the color sensations

FIG. 7.—POSITION ASSUMED BY A NEREIS WITH ONE EYE BLINDED.

experienced are those of the solar spectrum from left to right, namely, from red through orange, yellow, green, blue, purple to violet, at which point the ether vibrations have reached the enormous velocity of 727 millions of millions per second. Beyond this point, what is technically called the ultra-violet portion of the spectrum is reached, where the vibrations become too rapid to be appreciated by the eye, and they consequently cease to be luminous. For example, "When a wire is heated in a spirit lamp placed in a dark room the particles of which the wire is composed are thrown into a state of violent vibration. As the heat increases the vibrations increase in rapidity. They are communicated to the ether, which surrounds and permeates everything; and the movements thus set up—infinitely small waves in this infinitely big ocean which fills all space—are sent off on their journey in all directions. At first the undulations are too slow to affect the retina, though they affect the skin. We perceive that the wire is hot if we hold it to our cheek an inch or two away, but our eye reveals no change. As the heat increases the rate of the waves increases, and when they reach to the enormous number of about 450 billions—that is, 450 millions of millions—per second, we see that the wire is glowing red. The ordinary physical cause of sight, then, is found in the fact that undulations or vibrations of almost inconceivable rapidity are affecting an organ specially adapted for receiving them, viz., the retina. . . . If we think this over we shall see that it involves the conclusion that what we call light does not exist in the universe apart from eyes to see it. The 'light rays' that physical science deals with are, in themselves, no more red or blue than the dark heat rays or than the X-rays of which we have heard so much of late; the sunshine would have no splendor, but from the eyes which see it. If eyes did not exist, the sun's rays would produce their beneficent effects on plants and animals just as they do now, but the splendor and beauty would not exist. They are due, not to the physical cause, but to the mysteries of a piece of living tissue, the retina, which has been given the power to select those rays composed of undulations of a certain degree of rapidity, and to somehow make them the occasion of mental facts of unspeakable beauty." (Ryland. "The Story of Thought and Feeling.")

Having examined the nature of light and vision thus far, the question which naturally suggests itself is, how is the energy of light converted into a nerve impulse, and if, as seems probable, there are only three primary color sensations, by what means are these severally differentiated?

The retina consists of several distinct layers of living protoplasmic cells, the most remarkable of which are the layer of rods and cones, which are found on the surface, and which, consequently, are the first to receive the impressions of incident rays of luminiferous ether. What happens in these cells under its influence? We know by examination of other tissues that protoplasm has the power of forming in its life processes certain bodies called ferments, which, under certain conditions and in the presence of favorable surroundings, produce chemical changes, either katabolic (destructive) or anabolic (constructive), without themselves being in any way affected. For instance, the gastric cells produce a ferment called pepsin, which is able to convert the proteids of food into peptones; so also the pancreatic cells possess a ferment called amylopsin, which is able to convert starches into sugar, with the evolution of various forms of energy, chemical, nervous, etc. Is it not possible, too, in case of the retinal cells, that the process by which the energy of light is converted into nervous energy may be a process of fermentation, and that the ions of luminiferous ether, acting on the ions set free by a ferment body present in these protoplasmic cells, may produce katabolic, and possibly anabolic, changes, which, liberating electro-vital force and nerve stimulation, are conducted by the piliments of the optic nerve to the visual centers in the brain, to be there interpreted by the consciousness as sensations of light and color?

That light will produce these changes in the retinal cells is well illustrated by Waller's researches, and that the presence of ferment bodies in protoplasmic cells may, through ionic action, give rise to nerve force is supported by Dr. Allchin in a lecture given by him on "Nutrition and Malnutrition," reported in the Clinical Journal, April, 1905.

The former experiments are described in Halliburton's "Handbook of Physiology," as follows: "The excised eyeball of a frog is led off by non-polarizable electrodes to a galvanometer. One electrode is placed on the front, the other on the back of the eye. A current of rest (demarkation current) is observed passing through the eyeball from front to back. When light falls on the eye this current is increased; on shutting off the light there is a momentary further increase, and then the current slowly returns back to its previous condition. Waller explains this by supposing that anabolic changes in the eye predominate during stimulation by light. With the onset of darkness, the katabolic changes cease at once, and the anabolic more slowly; hence a further positive variation. If the eyeball has been excised the day before the observations are made, or has been fatigued or injured, light produces principally katabolic changes, as evidenced by a negative variation. A slight positive effect follows when the light is shut off."

On the question of ferment bodies producing nerve energy, etc., Dr. Allchin expresses himself as follows: "The vital activities of the living cells would seem to consist essentially in the formation of ferment bodies which alone, or in combination, affect those integrations and disintegrations which liberate chemical energy, and that this by transformation produces muscular work, nerve force, and secretory function, the fundamental manifestations of life. That these enzymes do bring about these changes in such conditions of temperature and alkalinity or acidity as obtain in the body appears to be certain, and as an explanation of the activity of the bioplasm, which elaborates these bodies, there is postulated an ionic action on the part of the cell contents, and their surrounding medium whereby charges of electricity of variable strength and character are brought into conflict, and that from the play of ions the manifestations of vitality result." Whether visual purple is of the nature of a ferment, as seems to be suggested by Hering's theory of color vision, is not at present known, neither has its presence been demonstrated in the human retina as far as I am aware.

That ionic action should be produced by light in the presence of a ferment contained in the retinal cells would not be incompatible with the Young-Helmholtz theory of color vision depending on three primary color sensations, red, green, and violet, if we suppose that there are present in these cells three ferments capable of specially responding to each of these radiations (or one ferment even having the property of three separate reactions in an ascending scale of katabolism). It is important to note the position in the spectrum of these three radiations. On the extreme left are those which give rise to the sensation of red, of comparative long wave-length; that is, those which act least powerfully on the photographic plate; in other words, whose actinic or disintegrating powers are least

FIG. 8.—A SNAIL CRAWLING BETWEEN A BLACK AND A WHITE WALL.

powerful of the luminiferous rays; in the middle are those which give rise to the sensation of green, where actinic action occupies an intermediate position; while at the extreme right are those of shortest wave-length, which give rise to the sensation of violet. These are the so-called "actinic waves," whose actinic action is greatest, and which act most powerfully on the photographic plate.

Therefore, granting that in accordance with the Young-Helmholtz theory there are in the retina rods and cones which answer to each of these three primary color sensations, and bearing in mind the above facts that the radiations producing them respectively occupy three fixed points in the spectrum, left, middle, and right, in an ascending scale of actinism (power to produce chemical change), I would suggest that an

* Knowledge.

tonic action is induced by these radiations in association with three distinct ferments present severally in the rods and cones specialized to receive them, each ferment being specially capable of producing katabolic changes under the influence of the particular radiation concerned, and out of the energy thus liberated three corresponding degrees of nerve stimulation arise to affect the nerve cells in the deepest layer of the retina, which, on being transmitted by the nerve fibers to the nerve cells in the visual centers of the brain, are interpreted by the consciousness as the above color sensations. The various other shades and color effects seen in nature are probably due, as the Young-Helmholtz theory teaches, to the different degrees of stimulation these three-color terminals receive. Thus, if a large number of rods or cones, responding to the radiations to the extreme left of the spectrum, are brought under the influence of these rays, and those which respond to green and violet are hardly affected by their corresponding radiations, the sensation would be red. If, however, orange is the color sensation produced, then it will be owing to the red terminals or rods and cones corresponding to red that are considerably influenced, the green rather more, and the violet only slightly so, etc. In bringing this paper to a close I must acknowledge my indebtedness to Watson's "Textbook of Physics," Ganot's "Popular Natural Philosophy," and Halliburton's "Handbook of Physiology."

NITROGEN AND THE SOIL.

By E. B. VORHEES.

ONE phase of the nitrogen problem has been solved, but it has reference to the possible gain of nitrogen to soils, and thus in a sense compensates for the losses, though it makes the question of losses none the less important. I have reference now to discoveries that have been made in regard to the symbiotic action of certain bacteria which give to the leguminous plants their power of absorbing nitrogen from the air, and dispose of the question, in the sense that so long as the farmer judiciously uses any one of this class of crops in his rotation, it will be possible for him to not only maintain, but to even increase, the nitrogen content of his soils and thus make the question of exhaustion from that standpoint one not to be feared. It seems to me however, that we have but reached the threshold in these investigations, for while as a matter of fact such a practice will result in adding this important element to the soil, it does not dispose of the question of the full utilization of the nitrogen acquired. We have many instances of attempts made to improve soils, or to maintain their fertility by the introduction of leguminous crops, which have proved disastrous rather than helpful in promoting plant growth or of permanently increasing fertility in this respect. Furthermore, we have no definite knowledge as yet as to the conditions which are necessary in order that the plants shall appropriate nitrogen from the air rather than from the soil, nor have we any definite information as to how large a proportion of the nitrogen so gathered is retained in the soil for the use of cereal and other crops which depend entirely upon soil sources for their nitrogen. I feel certain that no agricultural chemist of the present day would dare to risk his reputation on a positive statement in reference to any one of these phases of the question. The nitrogen question in agriculture is far-reaching in its influence, affecting not only those who cultivate the soil, but those who depend upon its products for their sustenance and profit; it is a question which has occupied the student of chemistry from the earliest times and the various theories advanced have caused no end of controversy among them, yet in many of its phases it is still a problem to be solved.—Abstracted from a paper read before the American Chemical Society.

CONSTANCY TO LIGHT OF ARTISTS' COLORS MOST FREQUENTLY USED.

IN the Münchner Kunsttechnische Blätter the painter, G. Bakenhus, gives an account of experiments carried on by him during a number of years with colors ground in oil and also with distemper colors, with the object of ascertaining their constancy to light. The colors were exposed to the light at the window of his studio for six years. The following were completely fast to light: Krems white, zinc white, Naples yellow (light), cadmium yellow (light, medium, and dark), light ocher, Roman ocher, brown ocher, gold ocher in thin layers, burnt light ocher, terra pozzuoli, Indian red, English red (light and dark), caput mortuum, Indian yellow, red lead, red and blue ultramarine, cobalt blue, chrome oxide, permanent green, cobalt green, terra di sienna (unburnt and burnt), gold ocher (burnt), umber (burnt and unburnt), Cassel brown, Cologne earth, Van Dyke brown, and asphalt in thin layers. In thick layers these colors suffered some alteration in shade. The following were only slightly altered: Naples yellow, zinc yellow, yellow ultramarine, cadmium orange, Vienna green, alizarine red, alizarine carmine, artificial vermilion (probably red lead colored with alizarine red). In the following the change was very marked: Paris blue, Berlin blue, Prussian blue, madder purple, madder brown, chrome yellow. The following were very much altered: Yellow and brown lakes, e. g., stil de grain, etc., also various sorts of green lakes. Carmine, scarlet lake, vermilion, and Chinese vermilion were entirely spoiled. It is evident that the artist has a large number of colors constant to light to select from, but that he must exercise caution in making the selection.

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